

24
BBB 2001

**BOTANICAL BIODIVERSITY
AND THE BELGIAN EXPERTISE**

**BOTANISCHE BIODIVERSITEIT EN DE BELGISCHE EXPERTISE
LA BIODIVERSITÉ BOTANIQUE ET L'EXPERTISE BELGE**



Cover illustration:

Dactylorhiza praetermissa in a linear relict between a pasture and an arable field.
Belgium, Knokke, Willem-Leopoldpolder, Dievegat, June 1998. Photo L. Vanhecke.

27 JAN. 2004

READING ROOM

G. Rappé
K. Busschots
E. Robbrecht
(editors)

BBB 2001
Botanical Biodiversity
and the Belgian expertise

Proceedings of a symposium held in October 2001
at the National Botanic Garden of Belgium

Botanische Biodiversiteit en de Belgische expertise
La Biodiversité Botanique et l'expertise Belge



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Volume 24

G. Rappé, K. Busschots & E. Robbrecht (editors)

BBB 2001. Botanical Biodiversity and the Belgian expertise. Proceedings of a symposium held in October 2001 at the National Botanic Garden of Belgium

The symposium and the publication of its Proceedings are a joint initiative of BIODIV and the National Botanic Garden of Belgium.



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Foreword

An increasing number of people worries about the constant decline of the fauna and flora, on a national as well as a planetary scale. The numerous associations for the study, conservation and protection of nature, from local working groups to large NGOs, are as many witnesses. After many international treaties were passed focusing on some particular aspects, the concern culminated in a broadly set up Convention on Biological Diversity. Belgium too has ratified this Convention and has immediately taken some initiatives. One of the first initiatives, started up by the working group 'Biodiversity' of BELNET (the federal scientific network) is the project BIODIV "Biodiversity Resources in Belgium". BIODIV, financed by OSTC (the Belgian Federal Office for Scientific, Technical and Cultural Affairs), draws an inventory of the knowledge and expertise on biodiversity present in Belgium, and makes this information readily available on a website (www.br.fgov.be/BIODIV).

The symposium BBB 2001, organised by BIODIV and the National Botanic Garden of Belgium, is part of these efforts. The National Botanic Garden of Belgium is the most important Belgian institute in the field of plant and fungal taxonomy. Both the palaeotropics and the European and Belgian phanerogamic and cryptogamic flora are studied. The Garden plays a major role in the obligations as a consequence of the ratification by the Belgian government of the CBD, the 'Rio Convention', certainly when it concerns botanical and fungal diversity.

The symposium was scientifically supported by a consulting committee with representatives from all universities and major research institutes. Its members also acted as promotion and liaison officer for their institute. Especially the last year students of botany of the academic year 2001-2002 were invited. The botanical associations have been requested to inform their members.

Organizing a conference and getting the proceedings printed is a major task. In this respect I like to thank the scientific committee, the BIODIV staffing (in particular Alain Vander Velde) and the organizing committee (in particular Chris Kosolovsky). My special thanks go to Kristien Busschots, who invested a lot in the preparation of this publication. Thanks also to Guido Rappé, who has been a driving force for the symposium and for the BIODIV project.

Jan Rammeloo,
Director National Botanic Garden of Belgium

Voorwoord

Steeds meer mensen maken zich ernstig zorgen over de achteruitgang van fauna en flora, zowel in eigen land als op mondiaal vlak. Getuige is het grote aantal natuurstudie- en natuurbehoudsverenigingen, van lokale werkgroepen tot grote NGOs. Nadat reeds eerder internationale verdragen werden gesloten rond één of ander zorgwekkend aspect, culmineerde de bezorgheid in een zeer breed geformuleerd 'Verdrag inzake Biologische Diversiteit' (CBD *Convention on Biological Diversity*). Ook ons land heeft deze Conventie geratificeerd en meteen een aantal

initiatieven genomen. Een van de oudste van deze initiatieven, gelanceerd door de werkgroep biodiversiteit van BELNET (het federale wetenschappelijke netwerk) is het project BIODIV "Biodiversity Resources in Belgium". BIODIV, gefinancierd door DWTC (de Federale Diensten voor Wetenschappelijke, Technische en Culturele Aangelegenheden), moet de kennis en de expertise op het vlak van de biodiversiteit die in België aanwezig is, inventariseren en op een overzichtelijke manier toegankelijk maken via een website (www.br.fgov.be/BIODIV).

Het symposium BBB 2001, georganiseerd door BIODIV en de Nationale Plantentuin van België, kadert in deze optiek. De Nationale Plantentuin van België is het belangrijkste Belgisch instituut op het vlak van taxonomie van planten en zwammen, met onderzoek op de fanerogamen en cryptogamen van de paleotropische, Europese en Belgische flora. De Plantentuin speelt een belangrijke rol in de verplichtingen als gevolg van de ondertekening door België van de CBD, de 'Rio Conventie', zeker wat betreft de biodiversiteit van planten en zwammen.

Het symposium werd wetenschappelijk begeleid door een comité met vertegenwoordigers van alle universiteiten en grote onderzoeksinstituten. De leden van het wetenschappelijk comité fungeerden ook als promotor en contactpersoon binnen hun instelling. Speciaal de studenten van 2de licentie plantkunde, academiejaar 2001-2002 werden uitgenodigd. De botanische verenigingen werden gevraagd hun leden op de hoogte te brengen.

Een symposium organiseren en de proceedings ervan drukkensklaar maken is veel werk. In dit opzicht wil ik de leden van de begeleidingscommissie, het personeel van BIODIV (in het bijzonder Alain Vander Velde) en van het organisatiecomité (in het bijzonder Chris Kosolovsky) danken voor hun inspanningen. Speciale dank gaat naar Kristien Busschots, die veel werk besteedde aan de voorbereiding van de proceedings. Dank ook aan Guido Rappé, de drijvende kracht achter dit symposium en achter het project BIODIV.

Jan Rammeloo,
Directeur Nationale Plantentuin van België

Avant-propos

Un nombre croissant de personnes s'inquiète du déclin constant de la flore et de la faune, à l'échelle nationale comme à l'échelle du Globe. Les nombreuses associations pour l'étude, la conservation et la protection de la nature, des groupes de travail locaux aux ONG les plus importantes, en sont autant de témoins. Après la conclusion de nombreux traités internationaux axés sur des aspects particuliers, l'inquiétude s'est manifestée au plus haut niveau par l'établissement d'une large Convention sur la Diversité Biologique (*CBD Convention on Biological Diversity*). La Belgique a ratifié elle aussi cette Convention et a pris immédiatement certaines initiatives. Une des premières initiatives à s'être concrétisée avec le groupe de travail "Biodiversité" de BELNET (le réseau scientifique fédéral) est le projet BIODIV, "Biodiversity Resources in Belgium". BIODIV, financé par les SSTC (les Services Fédéraux des Affaires Scientifiques, Techniques et Culturelles), élabore un inventaire des connaissances et de l'expertise belges sur la biodiversité et rend cette information disponible sur un site web (www.br.fgov.be/BIODIV).

Le symposium BBB 2001, organisé par BIODIV et le Jardin botanique National de Belgique, constitue une partie de ces efforts. Le Jardin botanique National de Belgique est l'institution belge la plus importante dans le domaine de la taxonomie des plantes et des champignons. Il étudie à la fois la flore phanérogamique et cryptogamique paléotropicale et celle de Belgique et d'Europe. Le jardin joue un rôle majeur dans les obligations résultant de la ratification par le gouvernement

belge de la CDB, la "Convention de Rio", en tous cas certainement en ce qui concerne la biodiversité botanique et mycologique.

Le symposium a été supporté scientifiquement par un comité consultatif composé de représentants de toutes les universités et instituts scientifiques majeurs. Ses membres agissaient en tant que promoteurs et personnes de contact dans leur propre institution. Les étudiants de dernière année en Botanique de l'année académique 2001-2002 ont été invités spécialement. Les associations ont été priées d'avertir leurs membres.

Organiser un congrès et en publier les actes est une tâche majeure. A ce point de vue, je tiens à remercier le comité scientifique, le staff BIODIV (en particulier Alain Vander Velde) et le comité organisateur (en particulier Chris Kosolovsky). Je remercie spécialement Kristien Busschots qui s'est beaucoup investie dans la préparation de cette publication. Merci aussi à Guido Rappé, qui a été le moteur de ce symposium et du projet BIODIV.

Jan Rammeloo,
Directeur Jardin Botanique National de Belgique

Scientific committee – Wetenschappelijk comité – Comité scientifique

NPB/JBN, Meise: Jan Rammeloo, Guido Rappé (organisers – *organisatoren* – organisateurs)

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RUG, Gent: Wim Vyverman

VUB, Brussel: Ludwig Triest

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BCCM, DWTC/SSTC, Bruxelles: François Guissart

Secretariat – Secretariaat – Secrétariat:

JBN/NPB-BIODIV (Guido Rappé, guido.rappe@br.fgov.be)



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Botanical Biodiversity and the Belgian expertise (BBB 2001), a Symposium and an Anthology – Preface to the Proceedings

Guido Rappé

BIODIV, National Botanic Garden of Belgium, Domein van Bouchout, B-1860 Meise, Belgium
guido.rappe@br.fgov.be

On October 19-20, 2001, the project BIODIV (“Biodiversity Resources in Belgium”) and the National Botanic Garden of Belgium organized a two-days symposium, with a double theme: the Belgian expertise in botanical diversity research and the botanical diversity of Belgium.

The symposium was given the acronym BBB 2001 – for the record and to avoid any ambiguity – standing for Botanical–Biodiversity–Belgium.

The term ‘biodiversity’, itself a contraction of ‘biological diversity’, originated in the 1980’s and has since gained international legitimization, especially since the presentation of the *Convention on Biological Diversity* on the UN Earth’s Summit at Rio de Janeiro in 1992. Its meaning is recognized in daily use in newspapers and other media.

The symposium covered the discipline botany in its broadest sense, including prokaryotes, “Algae” and “Fungi”, with the focus on **fundamental research of the wild botanical diversity: the autochthonous or indigenous flora.**

The first day, i.e. the Friday, was devoted to the professional botanic research done in Belgium. The target audience were the professional researchers, PhD students and last year’s students of botanical courses at the Belgian universities.

Lectures and posters gave an overview of the research at universities and research institutes in the field of botanical biodiversity, trying to avoid the theme of the second day. The aim was to have a presentation of every research unit in Belgium.

The second day, i.e. the Saturday, was devoted to the botanical biodiversity of Belgium. With this theme a large audience was targeted, practising and non-practising biologists, keen amateurs, professional and other associations, biology teachers, naturalists, journalists, nature conservation people, any interested individual,...

Any Belgian, Flemish, Walloon botanical research group or working group or association had the opportunity to present itself and its activities in the domain of biodiversity on a local, regional or national scale. At the end of the day the preliminary results of a national questionnaire on Belgian biodiversity were presented. This questionnaire aimed at drawing a national report on the status of indigenous fauna and flora, the ‘national monograph’, an obligation under the *Convention on Biological Diversity* for each country that has ratified the treaty. The National Botanic Garden of Belgium being the coordinator for the botanical contents, the work was carried out by BIODIV. The present volume contains the proceedings of the symposium. It offers articles and abstracts of

oral presentations given and posters displayed during the two days. Authors who wished to deposit a full text could do so. Others presented the results of work already published elsewhere or intended to be published in another journal or serial.

The contents of these proceedings are as diverse as nature itself. No particular subject 'jumps out', except maybe the fact that most work had been done on Belgian territory, on Belgian biodiversity. Some of it was done by professionals at a university or research institute. Other work is the result of dedicated efforts by naturalists. Still other work is of a hybrid nature: although sometimes done by qualified scientists, it often has nothing to do with the way they earn their living. In many respects 'scientists' are like 'artists', in the way they are driven, 'bitten' to do research, a creative act that often gains little reward except ones own esteem and – at best – that of 'fellow travellers'.

Some of the botanical work presented here are examples of scientific sparkles of the human mind.

These proceedings present an anthology (what a lovely word in this context: from the Greek *anthos* meaning 'flower') of Belgian botanical research in the domain of biodiversity, at the dawn of the 21st century and of the 3th millennium AD. They show that the study of botanical (bio)diversity is alive and very diverse itself.

Hopefully you will enjoy reading them.

The realization of this volume have taken up more time than intended. This was only partly due to the work of reviewing and editing the highly disparate manuscripts (last revised manuscripts received early 2003). The BIODIV team has had some personnel turnover and financing trouble and the work on the above mentioned 'national monograph' had to be given absolute priority.

We apologize for any inconvenience this may have caused to the authors and hope they are happy with the final publication.

Acknowledgements are due to Ivan Hoste for his much appreciated help with the desktop publishing, and to Machteld Sohier and Dominique Champluvier for linguistic aid.

Meise, September 2003

Postscript. – The term 'biodiversity' can now easily pass as an independent single noun. On the Internet one still marks a – logical – preference, at a ratio of 11:1, for 'botanical diversity' over 'botanical biodiversity'. Though we would not encourage the use of 'biological biodiversity', combinations as in 'botanical, floral, microbial, faunal, fungal, ... biodiversity' have a right to exist.

At the time of going to press of these proceedings I did a small exercise on the common use of 'biodiversity', 'biological diversity' and some combinations with 'diversity' and 'biodiversity', using the Internet search engine Google as a means. A distinction between 'philosophical' and 'natural' combinations was made. Philosophical adjectives or combinations refer to disciplines and subdisciplines of biological science, natural adjectives or combinations to subsets of living nature. The results are presented in table 1. The variation in sample size and ratio is large. The rows in bold concern the preferred or very often used combinations. Most often these also represent the largest sample sizes and thus the more popularly used expressions. There are no univocal hard conclusions to be made from the table. This should not come as a surprise: the use of language, both in its spoken and written form, is a living thing in itself, thus subject to evolution and variation. Living (and dead) languages, being communication systems of living beings, are to be considered as an integral part of the biodiversity of this planet.

Still, some trends are obvious. There is a clear preference for the use of 'diversity' over 'biodiversity'. The ratio diversity/biodiversity used in combinations varies between 2.3 and 29.5,

with a mean of 10.50 (the extreme values above 52 have been left out). There are only two exceptions: ‘biodiversity’ itself shows the opposite, largely replacing the original ‘biological diversity’, and the combination ‘mycological biodiversity’ also wins, but the difference and the sample size are small in the latter case. Another trend is the almost overall preference for ‘natural’ above ‘philosophical’ combinations. The only exception is the subject of these proceedings: ‘botanical diversity’ is encountered more often than ‘floral biodiversity’. Also ‘botanical’ is still largely preferred over its variant ‘botanic’.

Finally to those who are hard to convince that ‘biodiversity’ is here to stay: the pleonasmic combination ‘biological biodiversity’ yielded 730 responses!

Table 1. The use of ‘biological diversity’, ‘biodiversity’ and combinations with ‘diversity’ and ‘biodiversity’ on the Internet at the end of 2003, as revealed by the web browser Google.

‘philosophical’	‘natural’	diversity	biodiversity	div/bio	bio/div
(biological)		821,000	10,200,000	0.08	12.42
	bryophytic	0	0	n	n
phycological		2	0	n	n
bryological		8	0	n	n
	hepatic	12	0	n	n
mycological		28	53	0.53	1.89
	zoo-	41	0	n	n
myco-		115	0	n	n
	of bryophytes	127	55	2.31	0.43
	protistan	127	25	5.08	0.20
	of protists	138	20	6.90	0.14
microbiological		151	19	7.95	0.13
	of eukaryotes	161	2	80.50	0.01
	bryo-	195	0	n	n
zoological		212	47	4.51	0.22
	of prokaryotes	239	11	21.73	0.05
botanic		252	15	16.80	0.06
	of algae	366	59	6.20	0.16
	phyto-	537	4	134.25	0.01
	eukaryotic	821	39	21.05	0.05
	micro-	892	17	52.47	0.02
	algal	904	348	2.60	0.38
	of fungi	1090	210	5.19	0.19
	of bacteria	1180	74	15.95	0.06
	prokaryotic	1240	42	29.52	0.03
	floral	3460	500	6.92	0.14
	of animals	3540	207	17.10	0.06
	fungal	3710	1350	2.75	0.36
	faunal	4140	875	4.73	0.21
botanical		4440	381	11.65	0.09
	bacterial	5910	331	17.85	0.06
	of plants	13400	767	17.47	0.06
	microbial	20100	3290	6.11	0.16
overall total		67538	8741		
mean ratio				10.50	0.10

De botanische biodiversiteit en de Belgische expertise – BBB 2001: een Symposium en een Bloemlezing. Woord vooraf bij de Proceedings

Op 19 en 20 oktober 2001 organiseerden het project BIODIV (“Biodiversity Resources in Belgium”) en de Nationale Plantentuin een tweedaags symposium rond twee thema's, nl. de Belgische expertise op het vlak van botanisch biodiversiteitsonderzoek en de botanische diversiteit van België.

Het symposium kreeg als roepnaam het acroniem BBB 2001, wat staat voor Botanische Biodiversiteit België.

Het woord ‘biodiversiteit’, zelf een samentrekking van ‘biologische diversiteit’, ontstond in de jaren tachtig en heeft sindsdien internationale status verworven, vooral sinds de voorstelling van de *Convention on Biological Diversity* (Conventie betreffende Biologische Diversiteit) op de Wereld Top van de Verenigde Naties in Rio de Janeiro in 1992. Het woord wordt erkend door dagelijks gebruik in kranten en andere media.

Het symposium omvatte het vakgebied plantkunde in de breedste betekenis, met inbegrip van prokaryoten, ‘wieren’ en ‘zwammen’. De nadruk lag op het fundamenteel onderzoek van de wilde botanische diversiteit van België.

De eerste dag, een vrijdag, was gewijd aan het professioneel botanisch onderzoek in België. De doelgroep bestond voornamelijk uit professionelen, doctorandi en laatstejaarsstudenten van de plantkundeopleidingen aan de Belgische universiteiten. Aan de hand van voordrachten en posters werd die dag een overzicht geboden van het onderzoek, aan universiteiten en andere onderzoeksinstituten, op het vlak van de botanische biodiversiteit (zoveel mogelijk het thema van de tweede dag vermijdt). Er werd naar gestreefd dat elke onderzoeksgroep in België in het programma-aanbod zou vertegenwoordigd zijn.

De tweede dag, een zaterdag, was gewijd aan de botanische biodiversiteit van België. De doelgroepen waren in dit geval het breed publiek, actieve en niet-beroepsactieve biologen, amateurs, beroeps- en amateursverenigingen, natuurliefhebbers, biologielaars, journalisten, natuurbeheerders, geïnteresseerde individuen,... Die dag konden zowel professionelen als particulieren of leden van Belgische, Vlaamse en Waalse verenigingen en werkgroepen hun lokaal, regionaal en/of nationaal biodiversiteitsonderzoek voorstellen. Ook werden op het einde van dag de voorlopige resultaten voorgesteld van een nationale enquête betreffende de Belgische biodiversiteit. Deze enquête moet leiden tot een nationaal rapport, de ‘nationale monografie’, over het statuut van de inheemse fauna en flora. De nationale monografie is een verplichting voor elk land dat het biodiversiteitsverdrag (*Convention on Biological Diversity*) geratificeerd heeft. De Nationale Plantentuin van België was de coördinator van de botanische bijdrage aan dit rapport. De werkzaamheden hiervoor werden uitgevoerd door BIODIV.

Dit volume omvat de proceedings van het symposium. Het bevat artikels en abstracts van de lezingen en de posters die aangeboden werden gedurende de twee dagen. Sommige auteurs dienden een volledige tekst in. Anderen presenteerden de resultaten van werk dat reeds elders werd gepubliceerd of bedoeld was voor publicatie in ander tijdschrift of reeks.

Zijn inhoud is even divers als de natuur zelf. Geen enkel specifiek onderwerp domineert, behalve dan misschien het feit dat het meeste werk op het Belgische grondgebied gebeurde, op ‘Belgische’ biodiversiteit. Deels heeft dit werk betrekking op professioneel onderzoek aan universiteit of onderzoeksinstituut. Ander werk is het resultaat van toegewijd onderzoek door natuurliefhebbers. Nog ander werk is van een hybride natuur: hoewel uitgevoerd door een

gekwalficeerde onderzoeker, heeft het dikwijls niets uitstaans met zijn of haar broodwinning. In menig opzicht gelijken 'wetenschappers' erg op 'kunstenaars'. Ze zijn even gedreven, even gebeten om onderzoek te doen, een creatieve bezigheid die dikwijls weinig of geen beloning inhoudt, behalve misschien een goed gevoel en – in het beste geval – de waardering van geestesgenoten.

Een deel van het hier gepresenteerde werk zijn voorbeelden van dergelijke sprankels en vonken van de menselijke geest.

Deze proceedings geven een bloemlezing (wat een prachtig woord in deze context) van Belgisch botanisch onderzoek op het vlak van de biodiversiteit, bij het gloren van de 21ste eeuw en het 3de millennium AD. Ze illustreren dat de studie van de botanische (bio)diversiteit springlevend is en zelf ook zeer (bio)divers. Veel plezier met de lectuur ervan.

De realisatie van dit volume nam meer tijd in beslag dan voorzien. Dit was slechts gedeeltelijk te wijten aan het klassieke werk van reviewen en drukkensklaar maken van de sterk uiteenlopende manuscripten.

Het project BIODIV heeft enig personeelsverloop en financiële perikelen gekend. Bovendien diende het werk aan de hoger vermelde 'nationale monografie' absolute prioriteit gegeven worden.

Wij verontschuldigen ons hiervoor bij de auteurs en lezers, en hopen dat ze tevreden zijn met het resultaat.

Heel in het bijzonder is dank verschuldigd aan Ivan Hoste voor zijn zeer gewaardeerde hulp bij de desktop publishing en aan Machteld Sohier en Dominique Champluvier voor linguïstische bijstand.

Meise, september 2003

Naschrift. – Vandaag kan de samentrekking 'biodiversiteit' gemakkelijk doorgaan voor een enkelvoudig zelfstandig naamwoord. Op het Internet, voor zover dit een geschikt medium is om het taalgebruik in het Nederlands te testen, blijkt nog altijd een – logische – voorkeur te bestaan voor 'botanische diversiteit' boven 'botanische biodiversiteit', in een verhouding van 2 tegen 1. Hoewel we het gebruik van 'biologische biodiversiteit', om duidelijke redenen, niet zouden willen aanmoedigen, hebben combinaties zoals in 'botanische, microbiële of bacteriële, ... biodiversiteit' bestaansrecht verworven.

Net vóór het ter perse gaan van deze proceedings heb ik een kleine oefening gemaakt betreffende het gebruik van de termen 'biodiversiteit', 'biologische diversiteit' en sommige combinaties met 'diversiteit' en 'biodiversiteit', daarbij gebruik makend van de Internet Zoekmachine Google als voorbeeld. Ik maakte daarbij een onderscheid tussen 'filosofische' en 'natuurlijke' combinaties. Filosofische adjectieven verwijzen naar disciplines en subdisciplines van de biologische wetenschappen, natuurlijke adjectieven of combinaties naar onderdelen van de levende natuur. Het verschil moge blijken uit tabel 2, waar de resultaten gepresenteerd worden. Net zoals bij andere talen lopen het aantal ontvangen antwoorden en de verhoudingen erg uiteen. De totale omvang van de steekproef is echter gering, met dikwijls een nul op het request, in vergelijking met dezelfde oefening in het Engels. In het Nederlands, in sterkere mate dan in het Engels of het Frans, maakt men ook gemakkelijk een nieuwe samenstelling of behoudt men een omschrijving met een voorzetsel: 'dierendiversiteit' of 'biodiversiteit van (of aan) dieren'. De rijen in vetjes betreffen de meest gebruikte adjectieven of combinaties. Veel combinaties zijn minder gebruikelijk of onbestaande. Er zijn geen eensluidende harde besluiten te trekken uit de tabel. Zelfs in de keuze van het voorzetsel is men het oneens. Dit mag geen verrassing zijn: taalgebruik, zowel in zijn gesproken als in zijn geschreven vorm, is zelf een levend gegeven en dus onderhevig aan evolutie en variatie.

Levende (en dode) talen zijn communicatiesystemen van levende wezens, en moeten als zodanig beschouwd worden als integraal deel uitmakend van de biodiversiteit van onze planeet.

Sommige trends zijn wel duidelijk. Er blijkt een duidelijke voorkeur te bestaan voor het gebruik van ‘diversiteit’ boven ‘biodiversiteit’. De verhouding diversiteit/biodiversiteit varieert tussen 2 en 42, met een gemiddelde van 11. Er is één grote uitzondering: ‘biodiversiteit’ zelf toont een omgekeerde verhouding en vervangt duidelijk het originele ‘biologische diversiteit’. Een andere tendens is dat bijna overal een voorkeur voor ‘natuurlijke’ boven ‘filosofische’ combinaties is vast te stellen. De enige duidelijke uitzondering op deze regel is precies het onderwerp van deze proceedings: ‘botanische diversiteit’ scoort relatief hoog als adjectief en ook de combinatie ‘botanische biodiversiteit’ is één van de best ingeburgerde.

Tenslotte, voor diegenen die nog zouden betwijfelen dat ‘biodiversiteit’ een zelfstandig leven begonnen is: de pleonastische combinatie ‘biologische biodiversiteit’ werd zelfs 10 keer aange- troffen!

Tabel 2. Het gebruik van ‘biologische diversiteit’, ‘biodiversiteit’ en combinaties met ‘diversiteit’ en ‘biodiversiteit’ op het Internet, geïllustreerd met de zoekmachine Google op het einde van 2003.

‘filosofisch’	‘natuurlijk’	diversiteit	biodiversiteit	div/bio	bio/div
(biologische)		2120	15900	0.13	7.50
	van prokaryoten	0	0	n	n
	eukaryotische	0	0	n	n
	van microben	0	0	n	n
bryologische		0	0	n	n
	mossen-	0	0	n	n
	van paddestoelen	0	1	n	n
fycologische		0	0	n	n
algologische		0	0	n	n
	wieren-	0	0	n	n
	van wieren	0	0	n	n
	van eukaryoten	1	0	n	n
microbiologische		1	0	n	n
	aan microben	1	0	n	n
	aan bacteriën	1	0	n	n
	van mossen	1	1	1.00	1.00
	aan mossen	1	0	n	n
	paddenstoelen-	1	0	n	n
zoologische		1	0	n	n
	dieren-	1	2	0.50	2.00
mycologische		2	0	n	n
	bacteriële	5	4	1.25	0.80
	prokaryotische	6	2	3.00	0.33
	van bacteriën	17	0	n	n
	van dieren	27	3	9.00	0.11
botanische		53	26	2.04	0.49
	aan dieren	127	3	42.33	0.02
	van planten	129	39	3.31	0.30
	microbiële	132	9	14.67	0.07
	planten-	172	5	34.40	0.03
	aan planten	331	8	41.38	0.02
Algemeen totaal		1009	102		
Gemiddelde ratio				11.15	0.09

La biodiversité botanique et l'expertise belge - BBB 2001: un symposium et une anthologie. Préface aux Actes

Les 19-20 octobre 2001, le projet BIODIV ("Biodiversity Resources in Belgium") et le Jardin Botanique National de Belgique ont organisé un symposium de deux jours, axé sur un double thème: l'expertise belge dans la recherche sur la biodiversité botanique et la diversité botanique de la Belgique

Le symposium a reçu l'acronyme BBB 2001 - pour l'enregistrement et pour éviter toute ambiguïté - signifiant Biodiversité - Botanique - Belgique.

Le mot "biodiversité", contraction de "diversité biologique", est né dans les années '80 et a été légitimé depuis au niveau international, particulièrement depuis l'adoption de la *Convention sur la Diversité Biologique* au sommet mondial de la Conférence des Nations Unies sur le Milieu et le Développement en 1992 à Rio de Janeiro. La signification de ce mot est reconnue et utilisée quotidiennement dans la presse et les autres médias.

Le symposium couvrait la botanique dans son sens le plus large, incluant les procaryotes, "Algae" et "Fungi", avec en point de mire **la recherche fondamentale sur la diversité botanique sauvage: la flore autochtone ou indigène.**

Le premier jour, le vendredi, était consacré à la recherche botanique professionnelle en Belgique. L'audience visée était celle des chercheurs professionnels, des doctorants et des étudiants en dernière année de Botanique des universités belges.

Des conférences et des posters donnaient un aperçu de la recherche dans les universités et les instituts de recherche dans le domaine de la biodiversité botanique, en essayant d'éviter le thème du second jour. Le but était de pouvoir présenter chaque unité de recherche existant en Belgique.

Le second jour, le samedi, était consacré à la biodiversité botanique de la Belgique. Ce thème visait un large public, biologistes praticiens ou non, amateurs éclairés, associations professionnelles ou autres, enseignants en Biologie, naturalistes, journalistes, représentants de la conservation de la nature, et toute autre personne intéressée...

Tout groupe de recherche ou de travail, toute association, qu'elle soit belge, flamande ou wallonne, avait l'opportunité de se présenter et de faire part de ses activités dans le domaine de la biodiversité à l'échelle locale, régionale ou nationale. A la fin de cette journée, les résultats d'un questionnaire national sur la biodiversité de la Belgique ont été présentés. Ce questionnaire avait pour but de permettre l'élaboration d'un rapport sur la situation de la flore et de la faune indigènes, la "Monographie Nationale", une obligation imposée par la *Convention sur la Diversité Biologique* pour chaque pays qui avait ratifié le traité. Le Jardin Botanique National étant le coordinateur pour le contenu botanique de ce document, le travail a été confié à BIODIV.

Le présent volume contient les actes du symposium. Il offre des articles et des résumés des présentations orales et des posters exposés pendant les deux journées. Les auteurs qui souhaitaient déposer un texte intégral pouvaient le faire. Les autres ont présenté les résultats de travaux déjà publiés ou sur le point de l'être dans une autre revue ou un autre journal.

Le contenu de ce volume est aussi varié que la Nature elle-même. Aucun sujet particulier n'est mis en avant, mais on souligne le fait que la plupart des travaux ont été effectués en territoire belge, sur la biodiversité de la Belgique. Certains sujets ont été étudiés par des professionnels

d'universités ou d'instituts de recherche. D'autres travaux sont le résultat d'efforts consciencieux de naturalistes. D'autres encore sont de nature hybride: si certains ont été faits par des scientifiques qualifiés, ils n'ont rien eu à voir avec le moyen pour eux de gagner leur vie. A bien des égards, les scientifiques sont des artistes, en ce sens qu'ils sont entraînés, mordus par la recherche, un acte créatif qui n'offre souvent qu'une maigre récompense en dehors de l'estime de soi, et - au mieux - de celle des "compagnons de route". Certains des travaux botaniques présentés ici sont des exemples de "perles scientifiques" produites par l'esprit humain.

Ces actes présentent une anthologie (du grec *anthos* signifiant "fleur", quel joli mot dans ce contexte) de la recherche botanique en Belgique dans le domaine de la biodiversité, à l'aurore du 21ème siècle et du 3ème millénaire après J.C. Ils montrent que l'étude de la (bio)diversité botanique est vivante et elle-même très diversifiée.

Nous espérons que vous en apprécierez la lecture.

La réalisation de ce volume a pris plus de temps que prévu. Ceci est en partie dû au travail de révision et d'édition de manuscrits au caractère très disparate (derniers manuscrits révisés reçus début 2003). L'équipe de BIODIV a subi quelques remaniements de staff et a connu des problèmes de financement, et le travail sur la "Monographie Nationale", que nous avons évoquée plus haut, était absolument prioritaire.

Nous présentons aux auteurs nos excuses pour tout inconvenient qu'aient pu provoquer ces raisons et nous espérons que la publication enfin terminée leur procurera pleine et entière satisfaction.

Nos vives remerciements s'adressent à Ivan Hoste pour son aide à la mise en page et à Machteld Sohier et Dominique Champluvier pour l'aide linguistique.

Meise, septembre 2003

Post-scriptum. – La contraction "biodiversité" est tout-à-fait considérée maintenant comme une appellation en soi. Sur Internet, on relève toujours une préférence - logique -, avec un rapport de 3.7:1, pour "diversité botanique" contre "biodiversité botanique". Bien que nous ne désirions pas encourager l'utilisation de "biodiversité biologique", des expressions telles que biodiversité botanique, floristique, microbienne, faunistique, fongique..., ont le droit d'exister.

Au moment de mettre les actes sous presse, j'ai fait un petit exercice, en utilisant sur Internet le moteur de recherche "Google", sur l'usage courant des termes "biodiversité", "diversité biologique" et de certaines expressions incluant "diversité" et "biodiversité". Une distinction a été faite entre expressions "philosophiques" et "naturelles". Les adjectifs philosophiques se réfèrent à des disciplines et sous-disciplines des Sciences Biologiques, les adjectifs ou combinaisons naturels à des sous-ensembles de nature vivante. Les résultats sont présentés dans le tableau 3. La variation de la taille de l'échantillon et du rapport est large. Les rangées en grasses concernent les adjectifs préférés ou le plus souvent utilisés. En majeure partie, elles représentent aussi les plus gros échantillons et donc les expressions les plus populaires. Il n'y a pas de conclusions drastiques et univoques à tirer de ce tableau. Il ne faut pas être surpris: l'utilisation du langage, qu'il soit parlé ou écrit, est elle-même une chose vivante, donc sujette à évolution et variation. Les langues vivantes (ou mortes), systèmes de communication entre êtres vivants, doivent être considérées comme faisant partie intégrante de la biodiversité de cette planète.

Cependant, certaines tendances sont évidentes. Il y a une préférence marquée pour l'utilisation de "diversité" au lieu de "biodiversité" si le mot entre dans une expression avec un adjectif. Le rapport diversité/biodiversité tiré de l'usage des deux mots dans une expression varie entre 1,25 et 40, soit une moyenne de 9,06. Il y a seulement quelques exceptions. D'abord "biodiversité" utilisé pour lui-même montre la tendance opposée, remplaçant largement l'originelle "diversité biolo-

gique”. Les descriptions “biodiversité des algues” et “biodiversité des bactéries” sont plus fréquentes que la combinaison avec “diversité”. Une autre tendance est la préférence, quoique moins marquée qu’en anglais, pour les adjectifs ou descriptions naturels par rapport aux adjectifs philosophiques. Néanmoins, les expressions philosophiques contenant “botanique”, “faunistique” ou “floristique” sont très populaires.

Finalement, pour tous ceux qui sont difficilement convaincus que “biodiversité” est appelé à durer: l’expression pléonasmique “biodiversité biologique” engrange 390 réponses.

Tableau 3. L’usage à la fin de 2003 de “diversité biologique”, de “biodiversité” et de combinaisons avec “diversité” et “biodiversité” sur l’ Internet, en utilisant le moteur de recherche Google.

"philosophique"	"naturel"	diversité	biodiversité	div/bio	bio/div
(biologique)		48,700	201,000	0.24	4.13
myco-		0	0	n	n
phycologique		0	0	n	n
bactériologique		0	0	n	n
	bryophytique	1	0	n	n
algologique		2	0	n	n
bryologique		3	0	n	n
	bryo-	3	0	n	n
	des mousses	4	0	n	n
mycologique		5	1	5.00	0.20
zoo-	zoo-	5	0	n	n
	algale	7	4	1.75	0.57
zoologique		8	2	4.00	0.25
micro-	micro-	9	5	1.80	0.56
	des microbes	12	0	n	n
	fongique	20	16	1.25	0.80
	des algues	28	33	0.85	1.18
microbiologique		30	1	30.00	0.03
	des bactéries	56	120	0.47	2.14
	des fleurs	61	2	30.50	0.03
	des champignons	66	49	1.35	0.74
	florale	77	3	25.67	0.04
	phyto-	80	2	40.00	0.03
	bactérienne	80	30	2.67	0.38
	faunique	217	41	5.29	0.19
botanique		237	64	3.70	0.27
faunistique		255	68	3.75	0.27
	microbienne	297	194	1.53	0.65
	des animaux	460	36	12.78	0.08
	des plantes	799	184	4.34	0.23
floristique		870	191	4.55	0.22
<i>totale</i>		3692	1046		
<i>rapport moyen</i>				9.06	0.11



L'étude de la flore vasculaire de la Belgique et des régions voisines: passé, présent et avenir

Jacques Lambinon

Secrétaire de la *Nouvelle Flore* de la Belgique et des régions voisines,
Institut de Botanique, Sart Tilman, B22, B-4000 Liège, Belgique

Résumé. – Les étapes majeures, au cours des dernières décennies, de l'étude de la flore vasculaire de nos régions sont d'abord brièvement rappelées. La question est ensuite posée: comment tenir à jour et compléter les connaissances en question, en particulier quel est l'avenir de la Nouvelle Flore de la Belgique et de la Flora van België? La «veille documentaire» que cela implique, la diversité des informations à rassembler et le cas échéant à critiquer, les recherches à susciter, l'apport des approches modernes de la taxonomie... sont évoqués dans cette perspective. C'est là un programme qui reste vaste, malgré les «nuages» qui assombrissent, surtout en Belgique francophone, l'avenir des sciences naturelles.

Samenvatting. – Studie van de vaatplanten van België en de aangrenzende gebieden: verleden, heden en toekomst. De belangrijkste stappen in de studie van de vaatplanten van onze flora gedurende de laatste decennia worden kort overlopen. Aandacht wordt besteed aan de methodes om de kennis bij te houden en te actualiseren, waarbij in het bijzonder de vraag naar de toekomst van de Nouvelle Flore de la Belgique / Flora van België aan de orde is. In dit perspectief wordt aandacht besteed aan het bijhouden en opvolgen van de documentatie, het diverse karakter van de te verzamelen gegevens, de kritische evaluatie van de gegevens, de bijdrage van moderne taxonomische technieken... Het is een niet te onderschatten programma, zeker wanneer men de donkere wolken ziet die, vooral in Franstalig België, boven het onderzoek in de klassieke natuurwetenschappen hangen.

Abstract. – Study of the vascular flora of Belgium and the neighbouring regions: past, present and future. The major milestones of the study of the vascular flora of Belgium during the last decades are briefly mentioned. How can this knowledge be kept up-to-date and completed? What is the future for the national flora (Nouvelle Flore de la Belgique / Flora van België). Attention is paid to the many aspects involved: keeping up with the continuous stream of documentation, the disparate character of the information to be gathered, the critical evaluation of the data, the molecular approach in taxonomy,... . This task is not to be underestimated, since dark clouds are hanging over the future of the traditional natural sciences, especially in the French speaking part of Belgium. Translated by the editors.

Quelques étapes significatives de l'étude de la flore vasculaire

Il est impossible de faire ici un historique détaillé des étapes successives de l'étude de la flore vasculaire de la Belgique et des régions voisines et des travaux marquants réalisés en cette matière. Je me contenterai, en guise d'introduction et de façon plus thématique que chronologique, de citer quelques dates clés dont l'importance est évidente pour rendre compte de l'état actuel en ce domaine.

La première date retenue ici est 1950: c'est la publication, sous la plume d'André Lawalrée, du premier volume de la *Flore Générale de Belgique*, consacré aux Ptéridophytes. Dans l'introduction, Walter Robyns, directeur de ce qui s'appelait à l'époque le Jardin botanique de l'Etat, sis à Bruxelles, soulignait le fait que, pour déterminer les plantes vasculaires de notre pays, on ne disposait guère que du *Manuel de la Flore de Belgique* de François Crépin, dont la 5^{ème} et dernière édition, quelles qu'en soient les qualités, remontait à 1884 et était donc bien démodée. Œuvre de longue haleine, la *Flore Générale* devait s'intéresser ensuite aux Spermatophytes; 4 volumes complets, comprenant chacun 3 fascicules, et le fascicule 1 du volume 5 étaient réalisés, toujours par A. Lawalrée, avec quelques collaborateurs, à une cadence presque annuelle, jusqu'en 1966. Un dernier fascicule devait sortir de presse beaucoup plus tard, en 1993, consacré aux Ombellifères et réalisé par Régine Fabri. Le projet était alors définitivement abandonné, vu – comme l'écrivait alors Jan Rammeloo, l'actuel directeur de l'institution, transférée entretemps à Meise – le sentiment qu'il valait mieux «investir dans l'avenir plutôt que poursuivre une série pour le principe de la continuité». Il n'en reste pas moins vrai que la *Flore Générale* rassemble de multiples renseignements qu'il convient de ne pas laisser tomber dans l'oubli; son iconographie témoigne par ailleurs du talent exceptionnel des illustrateurs botaniques de notre pays. Les défauts de l'œuvre ont certes été soulignés, entre autres un cadre géographique étroitement limité à la Belgique et des données parfois trop livresques, notamment dans la rubrique dite «éthologique». C'est ainsi qu'il est bien difficile de faire la part de ce qui a réellement été observé en Belgique parmi les informations rassemblées tout au long de l'ouvrage concernant les champignons parasites et les zoocécidies. Il n'empêche que bien des données intéressantes et originales ont été acquises dans le cadre de la *Flore Générale*; parmi les exemples les plus récents, je ne citerai que les mises au point concernant certaines Ombellifères, notamment les *Oenanthe*, effectuées par R. Fabri.

Dans son introduction, en 1950, W. Robyns citait à juste titre les travaux menés au Jardin botanique pendant une dizaine d'années, avant la dernière guerre mondiale, par Raoul Mosseray, mais il passait sous silence le *Nouveau Manuel de la Flore de Belgique et des Régions limitrophes* du botaniste amateur liégeois Jules Goffart, dont trois éditions virent le jour entre 1935 et 1945. C'est peut-être un peu injuste, car, malgré des clés trop souvent confuses et des données chorologiques sommaires voire incohérentes, cette flore rendit malgré tout pas mal de services, au moins pour la partie francophone de la dition, jusqu'en 1967. Elle eut notamment comme mérite d'étendre le territoire pris en compte depuis le sud des Pays-Bas jusqu'aux côtes de la Manche, à la Champagne, à une partie de la Lorraine et à l'Eifel occidental. Dès lors, bon nombre de taxons absents de la flore de F. Crépin y figurent, de même d'ailleurs que diverses adventices. W. Robyns ne mentionnait pas non plus le *Catalogue des Ptéridophytes et Phanérogames de la Flore Belge* de Lucien Hauman et Simone Balle, paru en 1934; celui-ci intégrait pourtant les principaux progrès de la floristique belge jusqu'à cette date, par exemple concernant les *Rubus*, et systématisait l'usage des districts phytogéographiques tels que délimités par Jean Massart.

Un nouveau point de repère important est la publication, en 1967, de la *Flore de la Belgique, du Nord de la France et des Régions voisines*. Elle est due à l'initiative de William Mullenders, qui, dans son enseignement universitaire à Louvain comme dans ses recherches phytosociologiques, mesurait l'extraordinaire lacune que représentait l'absence d'une flore mise à jour de nos régions. Les auteurs en étaient J.-E. De Langhe, L. Delvosalle, J. Duvigneaud, J. Lambinon, A. Lawalrée, W. Mullenders et C. Vanden Berghen, aidés par quelques collaborateurs. Le territoire

couvert rappelait celui de la flore de Goffart, mais c'est là à peu près la seule similitude avec cet ouvrage. Toute une série de données étaient rassemblées : clés semi-descriptives des familles, genres, espèces et parfois taxons infraspécifiques, noms corrects et synonymie, noms vernaculaires, phénologie, écologie, distribution et fréquence dans les divers districts phytogéographiques, aire générale...

Malheureusement, cette flore avait dû être réalisée un peu trop rapidement, la coordination entre les auteurs avait été insuffisante, les données chorologiques étaient imparfaites et certains taxons avaient été négligés. Un nouveau programme était dès lors mis en chantier, animé par les mêmes auteurs, à l'exception de Lawalrée, Mullenders et par la suite Vanden Berghen, et quelques collaborateurs devaient s'ajouter. Cela déboucha sur la publication, en 1973, de la *Nouvelle Flore de la Belgique, du Grand-Duché de Luxembourg, du Nord de la France et des Régions voisines*. Cette date est aussi celle à partir de laquelle le Jardin botanique national de Belgique assura l'édition de l'ouvrage, concrétisant par là une coopération qui ne s'est jamais interrompue.

La *Nouvelle Flore* a connu jusqu'ici quatre éditions: en 1973 donc, puis en 1978, en 1983 et début 1993 (avec une réimpression en 1999). Une traduction en néerlandais, pas très satisfaisante au début mais maintenant bien peaufinée, accompagnée de mises au point, permettait la publication de la *Flora van België, het Groothertogdom Luxemburg, Noord-Frankrijk en de aangrenzende gebieden*, en 1985, puis en 1988 et enfin en 1998. Cette dernière édition, il faut le souligner pour le floriste francophone, constitue donc aujourd'hui la mise à jour la plus récente de l'ouvrage. Une cinquième édition de la *Nouvelle Flore* est en chantier et on espère la voir publiée à la fin de l'année 2002.

Si on compare les sept versions ainsi publiées entre 1973 et 1998, on peut être surpris du nombre important de corrections et additions apportées. Celles-ci ont, en majeure partie, été inventoriées et commentées dans une série de publications, peut-être un peu fastidieuses mais qui rassemblent de nombreuses données, les unes bibliographiques, les autres inédites jusque là; la dernière en date (J. Lambinon, 1998) commente la troisième édition de la version néerlandaise de la flore. La méthode de travail a toujours été de consigner sur des fiches toute modification apportée d'une édition à l'autre, depuis une simple faute d'orthographe jusqu'à la réécriture complète du traitement taxonomique de certains groupes. Ces fiches ont circulé régulièrement entre les auteurs et les collaborateurs et elles ont fait ainsi l'objet d'une critique constructive de leur part.

Tenir à jour et améliorer la *Nouvelle Flore* et la *Flora van België*

Le secrétariat de cette flore, que j'assure depuis bien longtemps, me permet de jeter un regard critique sur près de quarante ans d'activité taxonomique et floristique dans nos régions, d'en évaluer les acquis et les lacunes. Cela me conduit aussi – et c'est le plus important – à formuler une série de vœux et conseils pour l'avenir. Puissent-ils être utiles entre autres à celui ou ceux qui reprendront tôt ou tard, je l'espère, l'édition scientifique d'un ouvrage dont il est difficile de se passer, que l'on soit amateur ou professionnel, taxonomiste, floriste, phytosociologue ou engagé dans la protection de la nature... Je ne voudrais pas pour autant laisser croire que la taxonomie des plantes vasculaires en Belgique et dans les régions voisines, c'est avant tout l'édition de la *Nouvelle Flore* et de la *Flora van België*; cette réalisation, avec ses progrès successifs, est seulement un bon indice du succès et de la qualité de toute l'activité, de la plus modeste à la plus sophistiquée, dans le domaine de la géobotanique – pour utiliser un terme familier surtout aux germanophones –, dans nos régions, ainsi d'ailleurs qu'à l'échelle du continent.

De nombreuses questions pourraient être débattues. Je n'en retiendrai que quelques-unes, avec comme souci majeur de répondre à la question : quel est l'avenir de ces flores, quelle «veille documentaire» implique-t-il, comment tenir à jour et perfectionner cette œuvre...? Cela revient en

fait essentiellement à se demander comment parfaire dans l'avenir la connaissance de la flore vasculaire de nos régions.

1 La délimitation de la dition est-elle adéquate?

Sans doute, répondront probablement les auteurs. Il faut cependant se rendre compte qu'elle présente, pour une flore malgré tout régionale, un avantage ou un inconvénient, suivant le point de vue : c'est la richesse et la diversité de la flore lorsqu'on va de la Zélande à la Lorraine méridionale, en incluant soigneusement toutes les raretés, parfois même disparues. On comprend bien dès lors que nos collègues louvanistes B. Bastin, J.R. De Sloover, C. Evrard et P. Moens aient conçu et réalisé depuis 1985, à l'usage de leurs étudiants, une *Flore de la Belgique* simplifiée, limitée au territoire national et négligeant les raretés et les taxons critiques.

Dans la dition, et particulièrement en Belgique, devrait-on envisager à l'avenir une flore de la partie francophone et une de la partie néerlandophone ? L'idée ne me ravit guère, mais il y a des arguments en sa faveur, liés en particulier à la régionalisation dans notre pays de l'agriculture et surtout de la conservation de la nature.

En France, il existe une demande pressante pour étendre vers le sud, plus particulièrement vers le sud-ouest, la limite du territoire de la flore. Il y a à cela de bonnes raisons, notamment l'indigence du pays en flores modernes, mais aussi le caractère artificiel de la coupure actuelle; on doit par exemple être conscient que, lorsqu'il est question de «Picard méridional», c'est en fait de la partie sud du nord de la Picardie qu'il est question! La difficulté majeure d'une extension territoriale est l'absence d'une institution rassemblant les principales archives – et en particulier les herbiers – correspondant à l'histoire de l'exploration botanique de ces régions. Un espoir se trouve du côté des Conservatoires botaniques nationaux, en particulier celui de Bailleul, dont l'essor ne peut être qu'appelé de tous nos vœux, malgré les soubresauts qu'il a connus récemment.

L'inclusion dans le territoire de la *Nouvelle Flore* d'une portion de l'Allemagne, région d'Aix-la-Chapelle, Ardenne nord-orientale et Eifel occidentale, est enrichissante, car elle nous oblige à être attentif au dépouillement de la littérature allemande. Cela demande toutefois un investissement considérable en temps et bien entendu une connaissance suffisante de la langue. Les contacts ont jusqu'ici été trop peu suivis avec les botanistes locaux et il y a là un gros effort à faire dans l'avenir. Des collaborateurs luxembourgeois, pays où la phanérogamie semble connaître actuellement un certain «sommeil», malgré des travaux méritoires, sur les *Rubus* notamment, pourraient peut-être dans les prochaines années jouer un rôle prépondérant en cette matière?

2 La subdivision en districts phytogéographiques est-elle satisfaisante?

Dans l'ensemble, on peut répondre positivement, mais des problèmes subsistent. La coordination avec les pays voisins n'est pas parfaite, notamment avec les Pays-Bas. Ainsi, la Zélande est-elle rangée par les botanistes belges dans le district «Maritime» (où elle est toutefois individualisée comme une partie septentrionale, un peu singulière, de celui-ci), alors que les phytogéographes néerlandais considèrent la majeure partie de cette région comme un «Estuariëndistrict». Même en Belgique, la limite entre le Flandrien et le Campinien est-elle parfaitement dessinée? Le problème est plus compliqué encore dans la partie française du territoire pris en compte. Ainsi la délimitation des districts Boulonnais, Brabançon, Picard et même Champenois fait l'objet actuellement de réflexions avec des collègues du Conservatoire botanique de Bailleul¹. Si l'on étendait notre dition vers le sud-ouest, que ferait-on du Pays de Bray? En Lorraine, qu'est-ce vraiment que la Lorraine orientale et notamment comprend-elle ou non la vallée de la Moselle? Quant au Tertiaire Parisien, dont l'extension vers le sud a toujours été floue dans la *Nouvelle Flore*, comment le cartographier objectivement?

¹ Note de la rédaction: paru comme Toussaint B., Hendoux E. & Lambinon J. (2002) Définition et cartographie des territoires phytogéographique de la région Nord/Pas-de-Calais (France). *Lejeunia N.S.* 171: 31 p., 17 cartes.

En fait, on a sans doute trop fait confiance aux cartes géologiques et pédologiques pour délimiter ces phytochories, problème auquel se sont intéressés Roland Tournay, Martin Tanghe (cf. e.a. 1975) et d'autres. C'est en fait la flore – et dans une certaine mesure la végétation, y compris ce qu'elle doit à l'impact humain – qui sont déterminantes en la matière. Il y a là une exploitation des innombrables données cartographiques, publiées et inédites, à faire et peut-être une exploration nouvelle, pas à pas, à réaliser aux confins critiques des districts.

Quant à la fréquence de chaque taxon, exprimée le plus souvent par district, une objectivation de celle-ci demeure souhaitable, même si l'expérience empirique des floristes de terrain reste irremplaçable. Des essais dans ce sens sont très prometteurs, notamment celui tenté en 1999 par Vincent Boulet et ses collaborateurs dans leur *Inventaire de la flore vasculaire du Nord/Pas-de-Calais*, par le biais du calcul d'un «coefficient de Rareté régionale».

3 Le système taxonomique utilisé est-il parfaitement cohérent?

La réponse est non, mais aucun catalogue, aucune flore ne sont parfaits à cet égard. La question demanderait à elle seule tout un développement, qui s'intéresserait notamment à la redoutable question de la définition du genre, de l'espèce, de la sous-espèce..., à la valeur des caractères discriminants, aux apports en ce domaine des critères dits «modernes» – depuis l'anatomie jusqu'à la biologie moléculaire, en passant par la palynologie, la cytotaxonomie...

En Belgique et dans les régions voisines, nous avons connu des travaux novateurs en matière de taxonomie des plantes vasculaires, mais ils sont à mes yeux restés trop ponctuels. L'œuvre la plus importante est probablement celle de Paul Auquier, décédé prématurément en 1980, consacrée aux *Festuca* et aux *Vulpia*, utilisant largement l'anatomie, la cytotaxonomie, la culture expérimentale, la biologie de la reproduction... D'autres recherches participent du même esprit et se poursuivent aujourd'hui, comme celles du laboratoire de l'ULB animé par Claude Lefebvre et Pierre Meerts, sur les *Armeria*, le groupe de *Polygonum aviculare*, *Silene nutans*, les *Centaurea* de la section *Jacea*... A Liège, Anne Donneaux s'est intéressée aux *Galium*, particulièrement bien étudiés par les cytotaxonomistes hollandais; diverses données sont encore en grande partie inédites, comme celles relatives aux deux cytotypes de *Leucanthemum*, dont la prochaine édition de la *Nouvelle Flore* pourra profiter. Un travail sur le groupe de *Cardamine pratensis* en Flandre, mené à Gand, devrait être étendu à toute notre dition.

D'autres études taxonomiques, plus traditionnelles mais très méritoires, parfois avec des observations en culture expérimentale, devraient d'être énumérées. On citera par exemple celles de Jean Lebeau sur les *Mentha*, celles des bathologues dont Herman Vannerom, celles de Roland Tournay puis de Régine Fabri sur les *Bromus* du groupe *secalinus*, etc... On ne peut évidemment oublier les importants travaux menés sur les Orchidées de nos régions, mais on renverra pour cela à la synthèse réalisée à ce sujet dans le présent volume par Daniel Tyteca.

Dans beaucoup de cas, les auteurs d'une flore ne peuvent qu'avoir une opinion très incertaine quant à l'opportunité d'adopter ou non les conclusions taxonomiques de travaux menés ailleurs, ou de suivre le traitement de Med-Checklist, de Flora europaea, de Flora iberica, de Flora Nordica, de la *Standardliste* allemande de R. Wisskirchen et H. Haeupler – aussi bien documentée soit-elle – ou de quelque autre grande flore en cours de réalisation. Un exemple : beaucoup d'auteurs récents traitent comme genres distincts les *Persicaria* et les *Polygonum* s. str., lorsqu'ils n'individualisent pas en plus, outre les *Fallopia*, séparés ou non des *Reynoutria*, les *Bistorta*, les *Aconogonon*...; mais la 2^{ème} édition de Flora europaea, en 1993, garde un concept large du genre *Polygonum*! Le même type de problème se pose au rang spécifique et infraspécifique. Ainsi, faut-il maintenir le rang spécifique de *Lolium perenne* et de *L. multiflorum*, totalement interfertiles ? Faut-il reconnaître des sous-espèces chez *Silene nutans*, alors que le travail supposé biosystématique de D. Jeanmonod et G. Bocquet, publié en 1983, est en profond désaccord avec une analyse plus fine des populations belges (cf. e.a. F. Van Rossum, 2000)? Un « screening cytotaxonomique » beaucoup plus étendu qu'il ne l'est actuellement de notre flore reste largement souhaitable, surtout

à un moment où l'outil offert par la cytométrie de flux a ouvert des perspectives étendues dans une telle réalisation.

Quant à la taxonomie moléculaire, elle n'a sans doute encore donné, à l'échelle de notre dition, que peu de résultats importants au niveau de la définition et de la délimitation des taxons de rang spécifique et infraspécifique. Il y a pourtant déjà des acquis intéressants, comme ceux relatifs aux *Centaurea*, évoqués ci-avant. Citons aussi l'exemple d'un travail réalisé sur les *Elodea* (A. Vanderpoorten, J. Lambinon et M. Tignon, 2000), qui se base en partie sur une analyse macromoléculaire pour conclure qu'il n'y a aucune donnée fiable concernant la présence d'*E. callitrichoides* dans notre dition. C'est là une approche pleine d'avenir, dans laquelle le Jardin botanique national vient d'investir, en confiant à un chercheur nouvellement recruté la mise sur pied d'un laboratoire orienté vers ces questions.

Autre question que je puis à peine aborder ici: quel système taxonomique des ordres et des familles adopter dans l'avenir? Pour l'instant, le problème n'est pas mûr, le temps manque pour remanier la classification utilisée jusqu'ici. Mais une flore est entre autres, pour l'étudiant en particulier, une occasion d'appliquer localement des enseignements de systématique qu'il reçoit. Il serait souhaitable dès lors que la classification y soit aussi proche que possible du système phylogénique qui est en train de s'élaborer, grâce principalement à l'outil macromoléculaire. Quand on sait que les *Veronica*, voire les *Callitriche* seraient des *Plantaginaceae* et les *Euphrasia* et *Pedicularis* des *Orobanchaceae*, on voit quelles perspectives de remaniement cela ouvre pour l'avenir! Mais comment concilier cela avec le fait que, sans doute longtemps encore, notre délimitation traditionnelle des familles continuera à être utilisée dans les bibliothèques, dans les herbaria, voire dans les propos courants des botanistes?

4 De quels taxons faut-il traiter de façon détaillée?

Une série d'espèces indigènes ont disparu depuis un temps plus ou moins long de nos régions. Il est sans doute intéressant de les énumérer, en tant que données phytogéographiques instructives, mais faut-il les inclure dans des clés, indiquer leur nom vernaculaire, leur taille, leur phénologie...? Si la réponse est non, après combien d'années d'absence une espèce est-elle tenue pour éteinte? N'y a-t-il pas de chance qu'on la retrouve un jour?

Le problème posé par les xénophytes est bien plus compliqué. Certains sont actuellement analysés en détail dans la flore, d'autres font seulement l'objet d'une observation, incluant souvent des caractères diagnostiques et des données stationnelles, d'autres encore sont simplement énumérés. Le choix entre ces traitements est difficile. Certes, certains taxons ne seront très probablement plus jamais rencontrés chez nous; c'est le cas notamment des nombreuses adventices lainières récoltées jadis dans la vallée de la Vesdre, avec au moins une exception mémorable, celle de *Senecio inaequidens*, dont l'expansion est une des plus agressives qui aient été enregistrées. Pour toutes ces plantes disparues, voire l'ensemble des adventices, un inventaire calqué sur le remarquable *Alien plants of the British Isles* de E. J. Clement et M. C. Foster (1994) serait le bienvenu et permettrait d'en écarter un bon nombre de la *Nouvelle Flore*.

D'autre part, la flore xénophytique change rapidement. Certaines espèces, même un moment naturalisées ponctuellement, peuvent disparaître. D'autres au contraire se sont révélées plus ou moins récemment invasives, parmi lesquelles des hydrophytes (*Ludwigia* à grandes fleurs, *Myriophyllum aquaticum*, *Hydrocotyle ranunculoides*, *Crassula helmsii*...), des commensales des champs de maïs (*Panicum*, *Setaria*...), des plantes échappées des parcs et des jardins (*Amelanchier*, *Spiraea*, *Cotoneaster*...). Il faut évidemment les traiter en détail, ne serait-ce que parce que l'utilisateur de la flore qui les rencontre ne peut deviner a priori leur caractère xénophytique. Or ces plantes posent souvent de difficiles problèmes taxonomiques, encore insuffisamment étudiés chez nous, malgré quelques remarquables travaux, tel celui, tout récent, de Filip Verloove (2001) sur les *Panicum* de Belgique. La coopération de spécialistes étrangers – cette flore xénophytique ayant souvent une large distribution européenne – est particulièrement

précieuse; c'est ainsi que la prochaine édition de la *Nouvelle Flore* tirera grand parti de la révision, dans divers herbiers belges, d'*Oenothera* par K. Rostański (Pologne) et d'*Eragrostis* par R. Portal (France) [voir la toute récente monographie (2002) publiée par ce dernier]. Soulignons au passage que celui-ci fait partie des amateurs, ce qui montre bien que, épaulés par des centres de recherches, ceux-ci peuvent réaliser avec succès de tels travaux difficiles. C'est aussi l'exemple que nous fournit en Belgique F. Verloove et on voudrait qu'il soit imité par plus d'amateurs.

Toujours en ce qui concerne les xénophytes, la *Nouvelle Flore* assimile aux plantes indigènes celles qui sont naturalisées «depuis plus d'un siècle». Ce fut là une initiative malheureuse, car ce laps de temps est fort arbitraire et aucune adaptation n'a été effectuée depuis la première édition, remontant à près de 30 ans! Un nouveau système de catégories, allant d'«adventice» ou «subspontané» jusqu'à «naturalisé», «assimilé indigène» (c'est-à-dire archéonaturalisé et amphinaturalisé) ou «indigène» pourra, nous l'espérons, être mis en application dès la prochaine édition de l'ouvrage.

Resterait enfin à débattre du statut à réserver aux plantes cultivées, compte tenu aussi des modifications dans leur nomenclature qu'induit le dernier *International Code of Nomenclature for Cultivated Plants* de 1995. Daniel Geerinck a évoqué cette question dans plusieurs publications récentes consacrées à des ligneux. Le moins que l'on puisse dire est qu'il y a là aussi des problèmes taxonomiques et nomenclaturaux ardues. Par ailleurs, quels ligneux, par exemple, faut-il citer dans la flore et inclure dans la clé spéciale qui leur est dévolue? C'est là tout un débat, hors de propos ici, mais on soulignera au passage qu'il y a par exemple des espèces répandues en culture dans le sud-ouest de notre dition – le laurier, *Laurus nobilis*, en est un exemple –, alors qu'on ne les rencontre pas ou guère en Belgique.

5 L'ouvrage a-t-il les qualités didactiques souhaitables?

C'est un peu une gageure que de vouloir faire d'un même ouvrage un inventaire détaillé et critique de la flore vasculaire d'un territoire relativement diversifié, sans masquer les problèmes qui restent posés, un manuel de détermination pour taxonomistes chevronnés, et en même temps un livre d'initiation, ou presque, à l'identification botanique. Certes les clés ont été perfectionnées avec le temps, de même que le glossaire, l'illustration s'efforce de mettre en exergue les caractères diagnostiques, des remarques attirent l'attention sur des confusions possibles,...

Mais on ne peut nier que l'usage de l'ouvrage n'est pas facile. Le botaniste expérimenté en est mauvais juge, car il utilise rarement la totalité des clés, celle des familles en particulier, «sautant» d'une ligne à l'autre en éliminant d'un coup d'œil les taxons qu'il connaît ou croit connaître avec certitude. La qualité didactique doit être testée avant tout par les étudiants, les naturalistes débutants, les forestiers, les agronomes... Pour tirer parti de leurs tâtonnements, de leurs erreurs, il faut être à leur écoute. J'ai appris bien des choses des générations d'étudiants qui ont utilisé la *Nouvelle Flore*. Il faut à tout prix que, dans l'avenir, cette écoute persiste et que les remarques formulées par les utilisateurs, même si elles témoignent parfois d'une ignorance difficile à combler, soient prises en compte avec intérêt et souci de perfectionnement.

6 Autres problèmes et perspectives

D'autres questions devraient être abordées. Je n'ai guère évoqué entre autres les problèmes de nomenclature, le dépouillement indispensable de toute la littérature européenne et autre en ce domaine, les mises au point rendues nécessaires lors de chaque nouvelle édition du *Code*, par exemple, pour le dernier en date (2000), la liste étendue des «nomina specifica conservanda et rejicienda» ou les difficultés d'application que soulève le concept nouveau de basionyme cryptique.

On pourrait aussi débattre de l'usage, à déconseiller ou non, des noms vernaculaires, de l'introduction éventuelle dans la flore de données synécologiques et de précisions relatives au

statut de protection, ce qui n'est pas simple vu la diversité des législations dans les cinq pays concernés, sans compter les spécificités propres aux régions.

Enfin, la structuration future des informations rassemblées concernant la flore de la Belgique et des régions voisines mériterait d'être débattue. On s'est surtout polarisé jusqu'ici sur les «listes rouges» et les statuts de protection, matière de compétence aujourd'hui essentiellement régionale, mais la réalisation et la mise à jour permanente d'une base de données globale relative à la flore de notre dition ne devraient-elles pas être une des missions du Jardin botanique national?

On le voit, les questions posées et les perspectives évoquées sont loin d'avoir épuisé le sujet!

L'avenir de la taxonomie et de la floristique dans nos régions

Il est pourtant un dernier aspect qu'on ne peut passer sous silence. C'est celui de l'avenir de la formation des taxonomistes, de la place de la taxonomie et de la floristique dans l'enseignement et plus généralement dans notre société de demain, du sort futur de la documentation botanique et notamment des herbiers, jusqu'ici – il faut le reconnaître – plutôt enviable en Belgique... Cet avenir m'angoisse.

Au niveau de notre enseignement, notamment des universités, principalement en Communauté française de Belgique, les perspectives sont particulièrement sombres. Les sciences naturelles, botanique, zoologie, géologie..., perdent de l'importance; plus on parle de biodiversité dans les médias, moins on s'en préoccupe à ce niveau. J'ai traité longuement de ce problème dans un discours fait en 1999, au terme de ma présidence de l'Académie royale de Belgique (J. Lambinon, 2000). En bref, j'y soulignais le fait que l'université connaît une grave dérive utilitariste: il n'y a plus guère de place et surtout de moyens pour un programme dont on ne perçoit pas les retombées économiques immédiates. Cela conduit bien entendu à une dérive marchande et à une perte d'indépendance de la recherche. La biodiversité est sans doute en danger dans la nature, mais la menace la plus inquiétante est sans doute l'uniformisation réductrice des chercheurs, au travers de systèmes pervers comme l'«indice de citations», orchestré par la mondialisation des grandes firmes commerciales d'édition. En conséquence, comme l'écrivait déjà en 1995 mon collègue zoologiste Roland Libois, les sciences naturelles et particulièrement la taxonomie constituent «un domaine où la capacité d'expertise et de formation d'experts s'érode à vive allure». Ce n'est malheureusement pas l'appel lancé, aussi en 1999, par le Comité national des Sciences biologiques, insistant «sur la nécessité de donner une impulsion vigoureuse aux études taxonomiques, permettant d'assurer une part incontournable dans l'établissement des bases scientifiques de la conservation des ressources naturelles et des bases pratiques de la gestion du milieu», qui renversera la situation.

Ainsi à l'Université de Liège, où je viens de terminer ma carrière académique, l'orientation «biodiversité-environnement» disparaît des licences en Biologie végétale et en Biologie animale, des installations comme la Station scientifique des Hautes-Fagnes ou l'Observatoire du Monde des Plantes sont menacées de fermeture ou du moins de vie au ralenti, les crédits des bibliothèques sont rabotés...

Le sort de ce Jardin botanique, pour peu de temps encore «national», est tristement révélateur. Chacun sait que je me suis battu, mandaté notamment par l'Académie royale, pour tenter de maintenir son caractère fédéral, malgré la régionalisation du secteur de l'Agriculture. Je n'ai rencontré, de la part de la plupart des mandataires politiques francophones qu'incompréhension, désintérêt, voire mépris. «Des herbiers, une bibliothèque...», pensaient-ils sans doute, «c'est vraiment encore utile à l'époque d'INTERNET et de la mondialisation?».

En 2002, le Jardin botanique doit passer sous l'autorité de la Communauté flamande. Je n'ai aucun doute quant au fait que chacun continuera à y trouver l'accueil, l'aide et la coopération qui font la réputation de l'institution et qui sont si importants pour l'avenir de la taxonomie. Par contre,

est-on vraiment certain que la politique des nouvelles autorités de tutelle restera semblable à terme à ce qu'elle est actuellement ? Et surtout, est-on assuré que la Communauté française continuera à supporter les chercheurs francophones travaillant à Meise, ou du moins leur programme actuel axé sur l'étude de la biodiversité de la flore sauvage?

Dans une Communauté où le Jardin botanique national n'est, dans l'esprit de beaucoup, qu'un «arboretum» en Flandre, je suis inquiet pour l'avenir. Dans un pays où l'économie prime sur le scientifique et le culturel, dans un pays où un Premier Ministre annonce son intention de chasser les Académies du palais où elles perpétuent une tradition remontant à l'impératrice Marie-Thérèse, ceci sans même en avertir les intéressés, il faut s'attendre à tout, surtout au pire.

Références

Il est fait allusion dans cet exposé de synthèse à de nombreux travaux qui ne peuvent être tous cités. On trouvera ici seulement une orientation bibliographique, qui réunit principalement les références les plus explicitement indiquées dans le texte.

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Maïsakkers en biodiversiteitsonderzoek: zin of onzin?

Ivan Hoste

Nationale Plantentuin van België, Domein van Bouchout, B-1860 Meise, België
Ivan.Hoste@br.fgov.be

Samenvatting. – *De soortenarme onkruidflora van maïsakkers omvat nauwelijks soorten die voor het natuurbehoud van belang zijn en wordt in hoge mate beïnvloed door de specifieke kenmerken van de maïsteelt in West-Europa, zoals het overvloedige gebruik van herbiciden en drijfmest, het grotendeels ontbreken van vruchtwisseling en het gebruik van zware machines (met gevaar voor structuurbederf en verdichting van de bodem), die deel uitmaken van het machinepark van loonwerkers. Tevens is de maïsteelt via diverse mechanismen nauw verbonden met de gemondialiseerde economie. Al die factoren samen hebben tot gevolg dat de samenstelling van de onkruidvegetaties in maïsakkers in de voorbije decennia voortdurend is geëvolueerd. Precies die snelle opeenvolging van veranderingen maakt de maïsakkerflora relevant voor onderzoek in het kader van de huidige biodiversiteitscrisis (o.a. introductie en inburgering van ‘exoten’).*

Résumé. – *Les champs de maïs et l’étude de la biodiversité: thème sensé ou absurde? La flore des champs de maïs est assez pauvre en espèces et, qui plus est, très peu d’entre elles ont une importance réelle dans le contexte de la protection de la nature. Leur présence dans les champs est liée aux caractères spécifiques à la culture du maïs en Europe de l’Ouest: l’utilisation de grandes quantités d’herbicides et de purin, une rotation de cultures très limitée, l’emploi de machines lourdes (ce qui risque de dégrader la structure du sol) et la participation très importante de travailleurs agricoles indépendants. Par ailleurs, cette culture est étroitement liée à une économie largement mondialisée. De l’ensemble de ces facteurs il résulte que depuis quelques décennies la composition de la flore dans les champs de maïs a continuellement évolué. Cette évolution offre un cas intéressant pour étudier certains processus à la base de la crise actuelle de la biodiversité (p.ex. la naturalisation d’espèces ‘exotiques’ accidentellement introduites).*

Abstract. – *Maize fields and the study of biodiversity: worthwhile or not? The weed flora of maize fields contains only a limited number of species and hardly any of these have a real conservation value. To a high degree its composition reflects the characteristics of modern agrarian practices in western Europe, namely the use of large quantities of herbicides and slurry, limited crop rotation, and the use of heavy equipment (causing structural deterioration and compaction of the soil) by agricultural contractors. Furthermore the cultivation of maize is tightly interwoven with worldwide economic networks. In the past decades this has resulted in a constantly changing composition of the weed flora of maize fields. Precisely this rapid succession of changes makes the study of such vegetations interesting in the context of today’s biodiversity crisis (for instance introduction and naturalisation of ‘exotic’ species).*

Inleiding

Het pas sinds de jaren tachtig gelanceerde begrip biodiversiteit (Wilson 1988) is inmiddels deel gaan uitmaken van het vocabularium van alledag van heel uiteenlopende groepen in de samenleving. Het ontstaan en het succes van de term zijn onlosmakelijk verbonden met de groeiende bewustwording van het probleem van de verarming van de biologische verscheidenheid op regionale en mondiale schaal. Het is met andere woorden in de context van de 'biodiversiteitscrisis' dat het begrip 'biodiversiteit' op zo korte tijd overal in het taalgebruik is doorgedrongen. Tot de praktische vragen die erdoor worden opgeroepen, behoort het in kaart brengen van de soortenrijkdom van administratieve of natuurlijke regio's door middel van gerichte inventarisaties. Naturalisten¹, en met name amateurs floristen, zien hierin de bevestiging van bezigheden die, al dan niet gedreven door natuurbehoudsoverwegingen, al sinds lang tot hun werkterrein behoren, namelijk het maken van soortenlijsten en verspreidingskaartjes.

Een beperkt kransje floristen heeft in de voorbije jaren veel aandacht besteed aan de flora van de door het gros van botanici en floristen vermaledijde maïsakkers; zie o.a. Dirkse *et al.* (2001) en Hoste & Verloove (2001). Gemeten naar absolute soortenrijkdom of naar aanwezigheid van voor het natuurbehoud relevante inheemse plantensoorten, hebben maïsakkers weinig te bieden. De vrij recente steile opgang van deze teelt in Vlaanderen en de snelle veranderingen in de samenstelling van hun onkruidbegroeiingen, vormen echter een interessant onderzoeksterrein. Dit kan worden geïllustreerd aan de hand van enkele voorbeelden die ik vooral ontleen aan recente waarnemingen in delen van de Noord-Vlaamse Zandstreek, in het gebied tussen Brugge en Gent.

De uitbreiding van de maïsteelt in Vlaanderen

Hoewel maïs al sinds veel langer op bescheiden schaal als voedergewas geteeld werd, is de grote doorbraak ervan bij ons amper een kwarteeuw oud. De landschappelijke en ecologische impact van de sterk toegenomen teelt van deze hoog opschietende grassoort is niet gering. Een zeer aanzienlijke oppervlakte akkerland – en in mindere mate grasland – werd in de voorbije jaren omgezet in quasi permanente maïsakkers. De teelt van maïs wordt onder meer gekenmerkt door een overvloedig gebruik van drijfmest en herbiciden, het bewerken van het land met behulp van zware machines (met als potentieel gevolg structuurbederf en verdichting van de bodem), het inschakelen van het machinepark van derden (loonwerkers) en het grotendeels ontbreken van vruchtwisseling (jaar na jaar maïs op dezelfde percelen). De invloed van dit beheersregime op de akkerflora is diepgaand. Opvallend is b.v., als een gevolg van gericht herbicidegebruik, de recente verschuiving naar een groeiend overwicht van grassen ten koste van dicotyle onkruiden. Globaal genomen hebben de akkergemeenschappen fel geleden onder de intensivering van de landbouw (inclusief zware bemesting en toegenomen onkruidbestrijding; Haveman *et al.* 1998). Dit fenomeen is wellicht nog eens extra benadrukt in gebieden waar de maïsteelt zich sterk heeft uitgebreid. Niet alleen is het gros van de percelen soortenarmer geworden; daarnaast vertalen

¹ In het Nederlands is het begrip 'naturalist', waarvan de Franse en Engelse pendant minder het stempel 'verouderd' dragen, grotendeels in onbruik geraakt. Van Dale Groot woordenboek der Nederlandse taal (13de druk, Utrecht/Antwerpen, 1999) geeft aan dat het woord in de hier bedoelde betekenis, nl. 'natuuronderzoeker', verouderd is. Dit kan niet los worden gezien van de ontwikkeling van de oude 'natuurhistorie' tot academische disciplines als biologie, ecologie, enz. in de voorbije paar eeuwen. Toch bestaan er volgens mij voldoende argumenten om het woord naturalist – met een positieve connotatie! – in ere te herstellen. Zo kan op een zinvolle manier de wijde kloof die de bioloog scheidt van de 'natuurliefhebber' taalkundig grotendeels worden overbrugd. In het begrip naturalist staat dan niet zozeer het statuut als amateur centraal (verschillend van de academicus of professional), maar wel elementen zoals kritisch, eigen, op veldwerk gesteund natuuronderzoek, kennis verdiepende ideeënuitswisseling met andere onderzoekers, kennisname van wetenschappelijke literatuur en het publiceren van originele (d.w.z. nieuwe feiten aanbrengende), niet louter vulgariserende bijdragen.

variaties in de bodemkenmerken zich vermoedelijk minder dan voorheen in de samenstelling van de onkruidbegroeiingen.

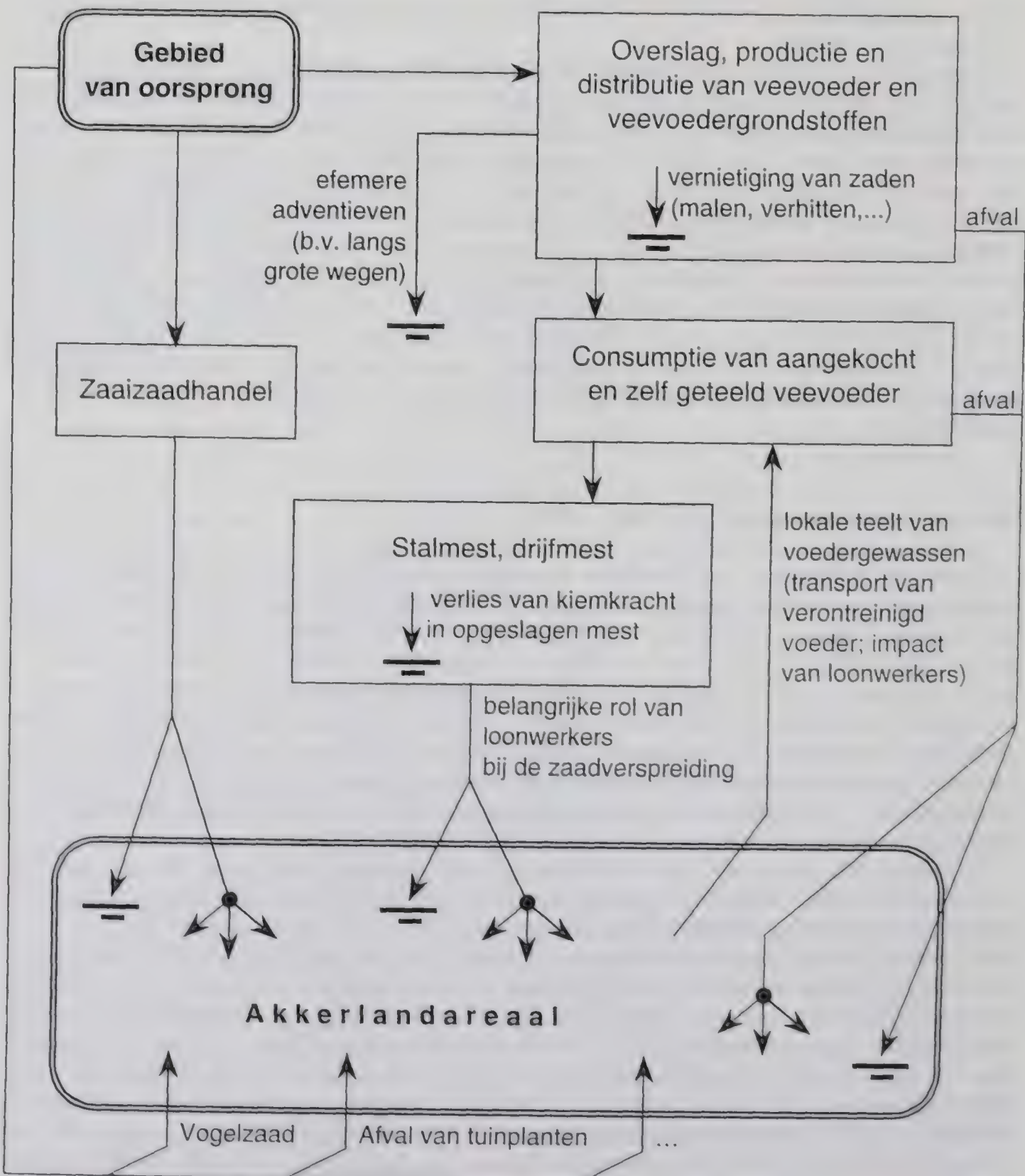
In grote delen van de Noord-Vlaamse Zandstreek nemen gewassen voor de lokale veestapel (grasland en maïsakkers) vandaag het leeuwendeel van het landbouwareaal voor hun rekening. Deze evolutie, gepaard gaand met een sterke inkrumping van onder andere de graanteelt voor menselijke consumptie, zou ondenkbaar geweest zijn zonder het ontstaan van een sterk geëxpandeerd – vandaag zelfs wereldomspannend – economisch netwerk. Van belang voor de onkruidvegetaties in maïsakkers zijn in dit verband de aanvoer uit andere delen van de wereld van zaaigoed en vooral van veevoeder en grondstoffen voor de veevoederproductie. De mechanismen waardoor nieuwkomers uit verafgelegen gebieden er in slagen een plaatsje te veroveren in akkergebieden, zijn dikwijls nog zeer onvoldoende gekend. Vermoedelijk moet vaak niet zozeer gedacht worden aan directe aanvoer van onkruidzaden met zaaigoed. Minstens even plausibel is een wat langere ketting van opeenvolgende schakels: aanvoer samen met veevoedergrondstoffen, gevolgd door voederproductie, -distributie en -consumptie, en tenslotte transport naar het land via stalmest (fig. 1).

De maïsakkerflora: pover en saai, maar toch...

Gelet op de geschiedenis en specifieke kenmerken van de maïsteelt in Vlaanderen, is in maïsakkers de kans op het vinden van inburgerende of pas sinds kort ingeburgerde plantensoorten relatief groot. Daarmee worden dan wel degelijk deze soorten bedoeld die zich blijvend vestigen en niet de talrijke min of meer toevallig en kortstondig optredende adventieven, die b.v. aangevoerd worden met vogelzaad of tuinafval. Hoe lang zo'n nieuwkomer al aanwezig is op het moment van ontdekking, is in de regel moeilijk te zeggen. De grootte van de populatie(s) en van het areaal kunnen vage indicaties geven, maar doorgaans ook niet meer dan dat. Omdat in het verleden bijzonder weinig verzameld werd in dit soort milieus, is bovendien de kans gering dat controleerbare – niet zelden verkeerd of niet gedetermineerde – oudere specimens van de plant in behoorlijke aantallen in herbaria op herkenning liggen te wachten.

Tegenover het inburgeren van nu en dan een nieuwe plantensoort staat een veelheid van efemere adventieven. Voorafgaand aan de doorbraak van een inburgerende soort, zal een plant dikwijls eerst jarenlang alleen nu en dan als adventief opschieten in diverse milieus, zoals graanoverslagplaatsen, wegbermen of eventueel ook akkers. De mechanismen die ervoor zorgen dat een plant zich na verloop van tijd manifesteert als een inburgeraar in plaats van een efemere adventief, zijn alweer niet goed gekend. Dit maakt het formuleren van voorspellingen moeilijk. Wel is het in het geval van onkruiden in maïsakkers heel waarschijnlijk dat het vervoer van zaden door loonwerkers een belangrijke rol speelt. In die richting wijst b.v. de aanwezigheid van typische C₄-grassen van maïsculturen op en rond inkuilplaatsen van veevoeder, ook wanneer het inkuilen niet direct in de omgeving van een maïsakker is gebeurd. Bij soorten met een voorlopig (?) nog beperkt areaal, waarvan vermoed wordt dat ze pas recent geïntroduceerd werden, zou het interessant zijn na te gaan of het verspreidingspatroon overeenkomsten vertoont met de actieradius van bepaalde loonwerkbedrijven in de regio.

Het determineren van een onbekende plant, het vergelijken met beschrijvingen en illustraties in vreemde flora's en met herbariummateriaal, uitmondend in de stellige zekerheid een 'nieuwe' gevonden te hebben, behoort tot de prettige momenten in het bestaan van een amateur florist. Een dergelijke bezigheid en bijbehorend enthousiasme worden nogal eens afgedaan als nutteloos verzamelaarsgedrag. Het vaststellen van de precieze identiteit van een plant is echter een eerste vereiste indien we de herkomst en de ecologie in het gebied van oorsprong willen kennen en de mogelijke uitbreiding en impact ervan in West-Europese ecosystemen willen inschatten.



Andere mogelijke aanvoerroutes in het agrarisch ecosysteem

Figuur 1. Een selectie van mogelijke routes die zaden van niet-inheemse plantensoorten kunnen volgen tijdens het proces van inburgering als nieuwkomers in (maïs-)akkers.

Anders dan bij adventieven, kan de vondst van een inburgerende soort veel meer zijn dan een floristisch primeurtje, al staat op het moment van ontdekking veelal nog niet vast of de plant een 'blijvertje' zal blijken te zijn of niet. Een indicatie voor werkelijke inburgering is de grootte van de aangetroffen populaties. Daarnaast biedt ook enig onderzoek in de internationale literatuur (inclusief het internet) goede aanknopingspunten. Nieuwkomers blijken dikwijls al eerder elders in de wereld – b.v. in de buurlanden, in de V.S. of in Australië – te zijn opgedoken en hebben zich daar eventueel tot lastige onkruidsoorten (*weeds*) ontwikkeld.

Alerte natuuronderzoekers met een goede streekennis zijn uitstekend geplaatst om al vroeg de inburgering van een nieuwe soort in hun omgeving vast te stellen. En dat is een cruciaal punt: het gros van de inburgeringsprocessen is al een hele tijd aan de gang op het moment dat iemand als eerste opmerkt dat er iets aan het gebeuren is, waardoor het fenomeen niet optimaal gedocumenteerd wordt. Een goed en vooral snel op de feiten inspelend communicatienetwerk tussen actieve floristen en botanici is hierbij van groot belang. Publicaties over recente vondsten, met de nodige aandacht voor goede beschrijvingen, determinatiesleutels en illustraties, werken het beschikbaar komen van nieuwe verspreidingsgegevens sterk in de hand. Ook informatie over eventueel te verwachten soorten – waarvan gekend is dat ze b.v. in de buurlanden aan een opmars begonnen zijn – kan voor dit soort onderzoek heel nuttig zijn. Wel dient onderstreept dat de kennistoename die door deze publicaties gegenereerd wordt, niet zonder meer mag verward worden met de snelheid van het werkelijke proces van inburgering of areaalsuitbreiding van de betreffende soort. Een gedetailleerd overzicht van de huidige status in Vlaanderen van deze groep plantensoorten biedt Verloove (in druk).

De opgang van de C₄-grassen

Ik wil het bovenstaande kort toelichten aan de hand van de recente opgang van C₄-grassen in maïsakkers. Deze grassoorten, waartoe ook maïs zelf behoort, zijn in de regel gebonden aan een iets warmer klimaat. Ze ontkiemen laat, maar compenseren dit al spoedig door een meer efficiënte fotosynthese en snellere groei, waardoor ze hun levenscyclus toch zonder veel problemen in de loop van de zomer rondkrijgen (Weeda *et al.* 1994). Geholpen door een sterk verbeterde onkruidbestrijding van dicotylen, hebben diverse C₄-grassen in maïsakkers een ideaal biotoop gevonden. Het warmte- en lichtminnende karakter van deze planten komt onder meer tot uiting door hun voorkeur voor zonnige, veelal zandige (en dus snel opwarmende), niet door bomenrijen beschaduwde akkerranden. Op het gros van de groeiplaatsen komen ze duidelijk meer voor in de akkerrand dan dieper in de percelen zelf, m.a.w.: ze gedragen zich veelal eerder als 'maïszoomplanten' dan als werkelijke 'maïsakkerplanten'.

Tabel 1, met gegevens van een recent uitgevoerde inventarisatie (Hoste & Verloove 2001), maakt duidelijk dat de huidige maïsflora-onderzoeker voor het determineren niet kan volstaan met een algemene flora. De snelheid waarmee de maïsflora – en onze kennis ervan – evolueert, maakt het onmogelijk om een flora geheel up-to-date te houden, zelfs indien elke nieuwe editie gepaard gaat met talrijke aanvullingen en correcties. Een 'maïsflorist' is daarom in hoge mate aangewezen op andere, periodieke publicaties.

Het opnemen van heel zeldzame adventieven in de determinatiesleutels van de meest gebruikte veldflora's verhoogt in hoge mate de kans op ontdekking van inburgerende of ingeburgerde populaties. Het maakt de actieve florist alerter en voorkomt verkeerde of doodlopende determinatie wanneer hij geconfronteerd wordt met iets wat nieuw of merkwaardig lijkt. Vooral in het geval van complexen van sterk op elkaar lijkende soorten, is dit soort voorkennis niet zonder belang. *Panicum dichotomiflorum* en *P. schinzii* vormen een dergelijk duo. De beide soorten hebben momenteel in Vlaanderen blijkbaar een sterk verschillende verspreiding.

Tabel 1. Verspreiding van enkele grassen in een rechthoek van 320 km-hokken tussen Brugge en Gent, met toevoeging van de beschrijving van hun status in de Flora van België.
“A” algemeen; “VA” vrij algemeen; “VZ” vrij zeldzaam; “Z” zeldzaam; “ZZ” zeer zeldzaam.

	Aantal km- hokken	Aangetroffen in en langs maïsakkers (+ eventueel in andere milieus)	Status in het Vlaams district volgens Lambinon <i>et al.</i> (1998)
<i>Echinochloa crus-galli</i>	315	314	“A”
<i>Setaria verticillata</i>	266	264	“Z-ZZ of ontbrekend” (VI. district niet apart vermeld)
<i>Digitaria ischaemum</i>	133	131	“VA-VZ”
<i>Panicum dichotomiflorum</i>	104	101	? (alleen vermeld als adventief voor het gebied van de Flora)
<i>Setaria viridis</i> subsp. <i>viridis</i>	78	71	“VA-VZ”
<i>Digitaria saguinalis</i>	84	68	“VA-VZ”
<i>Setaria verticilliformis</i>	55	54	“ZZ”
<i>Setaria macrocarpa</i> (= <i>S. faberi</i> auct. eur. et amer. non Herrm.)	23	21	? (alleen vermeld als adventief voor het gebied van de Flora)

Zelf vond ik *P. schinzii* tot nog toe nergens in het gebied tussen Brugge en Gent, terwijl *P. dichotomiflorum* in een zorgvuldig geprospecteerde rechthoek van 320 km² in zowat eenderde van de kilometerhokken werd aangetroffen, vaak met vele honderden exemplaren (Hoste & Verloove 2001). In het Antwerpse zijn echter de beide soorten sinds enige tijd in maïsakkers ingeburgerd (Verloove, in druk).

Een tweede soortenduo – in Lambinon *et al.* (1998) behandeld als twee variëteiten van één soort – omvat *Setaria verticillata* en *S. verticilliformis*. De twee taxa lijken qua habitus heel sterk op elkaar, maar zijn toch gemakkelijk te onderscheiden door de weerhaakjes op de borstels rond de aartjes: bij de eerste soort zijn ze naar de voet van de borstel gericht, bij de tweede soort naar de top. Daardoor haken bij de eerste soort de bloeiwijzen later in het seizoen opvallend in elkaar, wat *S. verticillata* dan vanop een grote afstand herkenbaar maakt. *Setaria verticilliformis* werd pas in 1990 voor het eerst in België waargenomen (Hoste & Verloove 2001), maar is in de jaren daarvoor allicht een tijdlang over het hoofd gezien. De beide soorten komen vaak samen in dezelfde percelen voor.

Pas in 2001 is duidelijk geworden dat *Echinochloa muricata*, een Amerikaans taxon dat qua habitus min of meer een dubbelganger is van de oorspronkelijk Europese en Aziatische *E. crus-galli*, in bepaalde delen van Vlaanderen wijd verspreid is. Recent omschreef Verloove (2000) *E. muricata* als een vermoedelijk slechts heel lokaal ingeburgerde grassoort. Nadat Filip Verloove me attent maakte op haar aanwezigheid ten NW van Gent, vond ik in talrijke maïsakkers in het hele gebied tussen Brugge en Gent grote populaties die voldoen aan de criteria om, op grond van Verloove (2000), *E. muricata* genoemd te worden. Vaak groeit de soort samen met *E. crus-galli*. Gelet op de ruime verspreiding, lijkt een heel recente vestiging en uitbreiding van dit taxon in Vlaanderen weinig waarschijnlijk. Logischer is het om aan te nemen dat *E. muricata* lang over het hoofd is gezien omdat de plant niet in de gebruikelijke determinatiewerken is opgenomen. Tevens maakt de grote vormenrijkdom van *E. crus-galli* het minder evident om in een plant met de habitus van *E. muricata* een zelfstandige soort te herkennen. De variabiliteit van de twee taxa – hoewel bij *E. muricata* geringer dan bij *E. crus-galli*? – heeft tot gevolg dat er bij het determineren van het materiaal soms probleemgevallen overblijven.

Niet alle auteurs blijken overigens helemaal overtuigd te zijn van de waarde van *E. muricata*. Begin jaren 1920 publiceerden Hitchcock (1920) en Wiegand (1921) vrijwel gelijktijdig twee revisies van de Noord-Amerikaanse soorten van het genus *Echinochloa*, waarin *E. crus-galli* en *E.*

muricata sterk verschillend werden behandeld. Het probleem lijkt ook vandaag nog altijd niet definitief te zijn opgelost. In de recente publicatie van Ryves *et al.* (1996) wordt *E. muricata* apart vermeld, maar dan wel met de opmerking “scarcely distinct from *E. crus-galli*”. Gelet op de blijvende onzekerheden, verdient het aanbeveling dat floristen geregeld getuigemateriaal zouden inzamelen om de aanwezigheid van de diverse taxa van het *E. crus-galli*-complex beter te helpen documenteren.

Een en ander maakt het weinig waarschijnlijk dat ooit een behoorlijke reconstructie zal kunnen gemaakt worden van de inburgeringsgeschiedenis van *E. muricata* in Vlaanderen en West-Europa. Zijn er toch enkele schaarse oude gegevens voorhanden – b.v. een vondst in Berlijn in 1915 (Scholz 1995) – dan blijft het een open vraag of dit een efemere adventiefvondst was zonder verder gevolg, dan wel een eerste indicatie van inburgering in West-Europa.

Een soort die betere kansen biedt om het proces van inburgering behoorlijk te documenteren, is *Setaria macrocarpa* (= *S. faberi* auct. eur. et amer. non Herrm.). In de Amerikaanse staat Illinois dook dit in oorsprong Chinese gras voor het eerst op in 1938. Daarna bereikte *S. macrocarpa* binnen de kortste keren elke county van de staat Illinois: “The rapid spread of this species is unbelievable”, noteerde Mohlenbrock (1973) bij dit fenomeen. Nadat de plant in ons land een tijdlang alleen gesignaleerd werd als adventief in havengebieden, bleek ze in de tweede helft van de jaren negentig ook aanwezig te zijn in maïsakkers (Verloove & Vandenberghe 1995, med. G. Heyneman 2001). Zelf zag ik *S. macrocarpa* in het gebied tussen Brugge en Gent voor het eerst in 1999. Anno 2001 is de plant in meerdere ver uiteen liggende akkers duidelijk ingeburgerd. In 2000, en meer nog in 2001, is in een geografisch beperkt gebied, gesitueerd in de omgeving van de kruising van het kanaal Brugge-Gent en het Schipdonkkanaal, een sterke toename van het aantal groeiplaatsen vastgesteld.

Tijdens het inventariseren van de flora van maïsakkers kunnen ook negatieve waarnemingen vragen oproepen. Een merkwaardige vaststelling in het gebied tussen Brugge en Gent is b.v. het totaal ontbreken van *Eragrostis*-soorten in en langs maïsakkers. Soorten uit dit geslacht worden in toenemende mate aangetroffen langs grote wegen, waar ze groeien in de voegen tussen kasseien of plaveien, d.w.z. in tredplantenmilieus. Ze delen dit milieu niet zelden met soorten uit de geslachten *Setaria*, *Digitaria* en *Echinochloa*, die alle tot de kenmerkende flora van maïsakkeranden behoren. Waarom die laatste soorten wél in de beide milieus voorkomen en *Eragrostis* alleen optreedt langs wegen, is niet duidelijk.

In de schaduw van het C₄-geweld

De recente belangstelling voor de flora van maïsakkers spitst zich vooral toe op de groep van de C₄-grassen en enkele andere C₄-planten, waaronder diverse soorten uit het geslacht *Amaranthus*. Door de late ontwikkeling van deze planten, loont het vooral in augustus-september de moeite om toch minstens eventjes aandacht aan dit biotoop te schenken. De vegetaties die vóór de opgang van de intensieve maïscultuur gedijden op de percelen waar nu *Echinochloa*, *Setaria*, *Panicum* en consoorten domineren, zijn grotendeels verdwenen. Toch zijn in dit milieu nog twee aspecten van de flora het vermelden waard.

Maïsakkers worden gekenmerkt door twee pieken in de ontwikkeling van eenjarigen. Voordat in het voorjaar de braakliggende akkers worden geploegd, ontwikkelt zich op korte tijd een vegetatie van kleine therofyten, die niet alleen zeer algemene soorten omvat (zoals *Erophila verna*), maar ook meer opmerkelijke soorten, zoals *Montia minor* – dikwijls massaal op wat nattere bodems – en *Myosurus minimus*. De ontwikkeling van deze vegetaties is deels afhankelijk van de natheid van winter en lente, die van grote invloed zijn op het tijdstip dat er kan geploegd worden.

Het is merkwaardig dat de intensieve maïscultuur, gepaard gaand met een overvloedig gebruik van drijfmest, niet alleen talrijke planten grotendeels uit onze akkers verdreven heeft, maar meteen ook gezorgd heeft voor kleine 'vluchtheuveltjes' in het verarmde landschap. Op de droge zandgronden van de Vlaamse Zandstreek vormen de met een laagje aarde afgedekte veevoederkuilen met gehakselde maïs minuscule toevluchtsoorden voor enkele planten van akkers en open bermen, die in andere milieus in de regio rake klappen hebben geïncasseerd. De vegetatie op en rond deze plekken is vaak opvallend rijk. Naast *Juncus bufonius*, *Gnaphalium uliginosum*, *Rumex acetosella* en *Spergula arvensis*, vind je er met een beetje geluk ook *Hypericum humifusum*, *Ornithopus perpusillus* en *Scleranthus annuus*. De laatste mij bekende groeiplaats in de regio van *Amoseris minima* was een zandig, droog hoekje van een akker, waar sinds een hele tijd jaarlijks maïs werd ingekuuld en waar ik in 1993 een kleine populatie aantrof.

Negatieve biodiversiteit?

De situatie anno 2001 in Vlaanderen bevestigt de vaststelling en voorspelling van Jauzein & Montegut (1983) betreffende de Franse onkruidflora: "Les Panicoïdes ont prospéré et à la 'trilogie' *Digitaria*, *Echinochloa*, *Setaria* s'est peu à peu substituée une 'tétralogie' en y adjoignant les *Panicum*, qui risque de faire du bruit." De mate waarin deze trend zich in de toekomst zal verderzetten is moeilijk voorspelbaar en is onder meer afhankelijk van de snel evoluerende methoden van onkruidbestrijding.

Twee sleutelfactoren zijn van belang om het succes van een reeks nieuwkomers in onze flora te begrijpen: enerzijds de globalisering van de handel (die de aanvoer van zaden uit de vier windstreken vergemakkelijkt), anderzijds de aanwezigheid van open niches (in dit geval het resultaat van belangrijke wijzigingen in de West-Europese landbouw). Bovendien moeten geschikte verbindingswegen de internationale aanvoerpunten van zaden verbinden met de potentiële inburgeringsmilieus (zie b.v. fig. 1). Ontbreekt één van die elementen, dan komt de introductie in de regel niet verder dan het stadium van een efemere adventief. Dit was b.v. het geval in de Vesdervallei, waar in de 19de-20ste eeuw een indrukwekkend aantal woladventieven werd aangevoerd, ingezameld en gedetermineerd (Visé 1942, 1958). Hoewel het fenomeen nooit systematisch vanuit die vraagstelling is onderzocht, kan toch gesteld worden dat de wolindustrie rond Verviers geen grote rol heeft gespeeld als 'uitvalsbasis' voor inburgeringsprocessen in een ruimer geografisch kader. Een spectaculaire uitzondering is *Senecio inaequidens*, oorspronkelijk een woladventief, maar – na meer dan een halve eeuw zonder opvallende expansie! – inmiddels in uiteenlopende milieus blijk gevend van nauwelijks te stuiten verbreidingscapaciteiten (Lebeau *et al.* 1978).

Biodiversiteit is niet louter een neutraal begrip. Eenvoudige, doorlopend genummerde inventarislijsten zijn dikwijls niet meer dan vrij grove hulpmiddelen bij het waarden van natuurgebieden en ecosystemen. Het ene nummertje in de lijsten wordt hoger gewaardeerd dan het andere, en ervaringen met al dan niet gewilde introducties van vreemde soorten in ecosystemen hebben geleerd dat 'meer' soms ook 'minder' kan betekenen. Nieuwe taxa zijn niet altijd welkome aanwinsten, zoals tot uiting komt in de term 'biological pollution' (Van Driesche & Van Driesche 2000).

De snelle uitbreiding van een aantal C₄-grassen lijkt zich momenteel te beperken tot milieus met een grote dynamiek (akkers, havengebieden, omgewoelde bermstroken, enz.) en met een geringe ecologische waarde. Dit is geen garantie voor een zorgeloze toekomst, maar sterkt toch het vermoeden dat van die nieuwkomers in de komende jaren weinig dreiging zal uitgaan voor de stabiliteit en integriteit van de levensgemeenschappen in belangrijke natuurgebieden. In dit opzicht zijn de consequenties van de opgang van de C₄-grassen in maïsakkers wellicht vergelijkbaar met

deze van de verrassend snelle uitbreiding en inburgering van enkele zogenaamde pekeladventieven langs de grote Vlaamse wegen in het voorbije decennium (Rappé 2000).

Tenslotte: waarom alleen aandacht schenken aan het puikje van het floristisch erfgoed?

Ik kan me inbeelden dat sommigen – of misschien zelfs velen – zich afvragen of het beschreven onderzoek in en langs maïsakkers iets bijdraagt aan het natuurbehoud. Het antwoord kan kort zijn: mocht er al sprake zijn van direct praktisch belang, dan zullen het eerder de landbouwers en agronomen zijn die er hun voordeel kunnen mee doen, en niet zozeer natuurbeschermers. De geregeld in maïsakkers opduikende nieuwkomers lijken zich netjes te houden aan de relatief nauwe begrenzing van hun doorgaans erg dynamisch voorkeurbiotop van akkers, omgewoelde bermen, enz. Ze verspreiden zich voorlopig niet of nauwelijks in milieus met een hoge natuurbehoudswaarde. Het succes van met name de C_4 -grassen in en langs maïsakkers illustreert eerder de gapende wonde van een open niche, ontstaan als een gevolg van diepgaande wijzigingen in een landbouwsysteem, waarvan intensivering en mondialisering de sleutelbegrippen zijn. Dat het succes van de warmteminnende C_4 -grassen ook iets zou te maken hebben met *global warming* kan niet worden uitgesloten, maar behoort met de huidige stand van onze kennis tot het domein van de niet bewezen speculaties.

Binnen de kring van naturalisten is het stellen van vragen betreffende de directe relevantie van natuurhistorisch onderzoek voor het natuurbehoud een bijna vanzelfsprekend uitvloeisel van de koppeling die vandaag vrijwel altijd wordt gemaakt tussen enerzijds belangstelling voor natuurstudie en anderzijds engagement ten gunste van het natuurbehoud. Ik wil er echter voor pleiten om de 21ste-eeuwse amateur florist, ornitholoog, entomoloog, enz. niet uitsluitend te stuwten in die ene richting van nuttig en noodzakelijk onderzoek ten gunste van het natuurbehoud, maar hem of haar ook wat ruimte te laten om in de schaarse vrije tijd geregeld eens gewoon te doen waar hij of zij zin in heeft. Het zou toch echt zonde zijn indien op termijn de fundamentele stimuli om aan amateur-natuurstudie te doen, zoals verwondering, nieuwsgierigheid en esthetische appreciatie, alleen nog zouden kunnen aangescherpt worden in die luttele procentjes van ons land die gezegend zijn met het predikaat 'reservaat'.

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Some notes regarding the taxonomical status of *Epipactis helleborine* var. *neerlandica* (Orchidaceae)

Walter Van den Bussche

Studiegroep Europese en Mediterrane Orchideeën – Vlaanderen, Heihoekstraat 188, B-9100 Nieuwkerken Waas
[walter.vdbussche@pi.be]

Abstract. – Since its original description in 1949, *Epipactis helleborine* var. *neerlandica* Vermeulen has been raised to subspecies and species level; some authors, without much comments, nowadays classify it as a species in the group of *Epipactis tremolsii*. The question remains as to what kind of research should be done in order to determine the rank of a taxon. In this article, an attempt is made to answer this question for *Epipactis neerlandica*. After three years of field study, some preliminary results are presented. With this paper the reader can also become more familiar with this taxon.

Samenvatting. – Nota's bij het taxonomisch statuut van *Epipactis helleborine* var. *neerlandica* (Orchidaceae). Sinds de originele beschrijving in 1949 van *Epipactis helleborine* var. *neerlandica* Vermeulen is dit taxon opgewaardeerd tot ondersoort en soort. Sommige auteurs klasseren het tegenwoordig, zonder veel commentaar, als soort in de groep van *Epipactis tremolsii*. De vraag blijft wat voor onderzoek gedaan moet worden om de rang van een taxon te bepalen. In deze bijdrage wordt een poging gedaan om deze vraag te beantwoorden voor *Epipactis neerlandica*. Hier worden enige voorlopige resultaten gepresenteerd van drie jaar veldwerk. De lezer kan met dit artikel ook het taxon beter leren kennen. Vertaald door de redactie.

Resumé. – Notes sur le statut taxonomique d'*Epipactis helleborine* var. *neerlandica* (Orchidaceae). Depuis sa description originale en 1949, *Epipactis helleborine* var. *neerlandica* Vermeulen a été élevé au rang de sous-espèce puis d'espèce. Certains auteurs, sans plus de commentaires, le classent aujourd'hui comme espèce dans le groupe d'*Epipactis tremolsii*. La question demeure de savoir quel type de recherches il faudrait réaliser pour déterminer le rang d'un taxon. Dans le présent article, un essai de réponse est donné concernant *Epipactis neerlandica*. Après trois années de recherches sur le terrain, quelques résultats préliminaires sont présentés. Ce papier permettra au lecteur de se familiariser avec ce taxon. Traduit par la rédaction.

Key words: *Epipactis helleborine*, *Epipactis neerlandica*, *Orchidaceae*

1 Taxonomical history

In 1958, the well-known Dutch orchid specialist Pieter Vermeulen published a detailed report in *Flora Neerlandica* on a special form of *Epipactis helleborine*, which he had found in the Amsterdamse Waterleidingsduinen and briefly described as a new taxon, var. *neerlandica* (Vermeulen 1949, 1958). Buttler (1986) placed this taxon at the rank of subspecies. Five years later, Devillers & Terschuren (in Delforge & al. 1991) made a new combination and raised this taxon to species level. In the second and revised edition of his "Guide des Orchidées", Delforge (2001) classified *Epipactis neerlandica* in the group of *Epipactis tremolsii*. The question is whether all these changes in rank are justified. Apart from the accurate description in Vermeulen (1949), none of the authors gave any comments or reason for raising the status of this taxon. Which argument(s) lead to the assignment of a taxon to a certain taxonomical level? How can this be verified? What kind of fieldwork can be used to find out which rank is proper for this *Epipactis neerlandica*?

2 Distribution and ecology of *Epipactis neerlandica*

Epipactis neerlandica can be found near or under the shrubs of *Salix repens* subsp. *dunensis* where the wind still has a chance to blow sand in and grasses *Poaceae* do not become too dominant. In this type of vegetation we find *Salix repens* subsp. *dunensis*, *Pyrola rotundifolia* var. *arenaria*, *Hippophae rhamnoides*, *Festuca juncifolia*, *Agrostis stolonifera*, *Viola canina* var. *dunensis*, *Viola hirta*, *Carex arenaria*, *Erigeron acer*, *Inula conyzae*, *Hypochaeris radicata*, *Listera ovata*, *Morchella esculenta* and sometimes also *Monotropa hypopitys* subsp. *glabra* and *Cephalanthera longifolia*. Sometimes *E. neerlandica* is found in bare dune sand, without any other vegetation in its immediate surroundings. However, in the soil one can easily find the roots of *Salix repens* or *Populus alba/canescens*. It is well possible that the fungi, that are ectomycorrhizal on these representatives of the Salicaceae, are also the ones that infect the seeds of this orchid. The relation between orchid and fungus is absolutely vital for the orchid; without the fungus the orchid seed can not germinate.

Up to now, *Epipactis neerlandica* has been found along the coast of Denmark (Jutland), Germany (Usedom, Ostfriesische Inseln), the Netherlands (Schiermonnikoog, Noord-Holland, Zuid-Holland, Zeeland), Belgium (West Coast) and France (Nord, Pas-de-Calais, Somme, Manche) (Jacquet 1995, S.F.O. 1998, Dekker 1999, Kreutz & Dekker 2000, Lemagnen 2002, Kreutz 2002, pers. obs.).

Pollination is effected by wasps: *Dolichovespula saxonica* (Fabricius), *Dolichovespula media* (Retzius), *Vespula germanica* (Fabricius) and *Vespula vulgaris* (Linnaeus). In Oostduinkerke pollination by *Discoelius zonalis* (Panzer) has also been observed. Other insects visit the flowers in search for food – e.g. bumblebees and digger wasps – but they do not remove the pollinia.

3 Differences between *Epipactis neerlandica* and *E. helleborine*

Epipactis neerlandica can be distinguished from *Epipactis helleborine* by the following characteristics (Vermeulen 1958; Kapteyn den Boumeester 1989):

- stem with leaves closely arranged in the lower part (*helleborine*: leaves more spread along the stem);
- sinuate leaves firm, erect and short, oval to round (*helleborine*: leaves larger and longer);
- lowest leaf often very near to the soil surface;
- flowering spike dense, flowers more hanging;

- very short bracts;
- flowering season starts at the end of July and lasts until the end of August (2-3 weeks later than *Epipactis helleborine*);
- margins of the leaf with papillae smaller than those of *helleborine*;
- papillae more or less forming an equilateral triangle;
- optimal in *Pyrolo-Salicetum*.

Sometimes one can find plants in the dunes with characteristics of *helleborine* as well as *neerlandica*. Such intermediate/transitional forms (hybrids?) are mostly found in other kinds of biotopes, such as dune woods or parks with plantations of *Pinaceae* or *Populus alba/canescens*. Extra research on this form is required to find out whether these plants are *Epipactis helleborine* adapted to extreme habitats (the dunes) or hybrids. It is well possible that this ecological type has reduced its length and the surface and position of the leaves on the stem. Their flowering period is the same as the inland populations of *helleborine*.

4 Material and methods

The research includes three components:

- Population dynamics: to learn more about the ecology of *neerlandica*.
- Biostatistics: is there a clear morphological distinction between *helleborine* and *neerlandica*?
- Behaviour: are the morphological differences between *neerlandica* and *helleborine* the results of an ecological adaptation to a new environment and are these differences genetically fixed?

Our research started in 1999. The study on the ecology of the population will only give satisfactory results if the period of investigation is long enough. As for the biometric part, the number of measurements through time as well as the number of different parts of the plants to be measured need to be sufficiently large to obtain reliable results.

We expect that by 2005 sufficient information will have been gathered for the three parts of the research to draw meaningful conclusions, although the research on population ecology will still be continued after that time.

4.1 Population dynamics

The studied population is situated in a permanent square of 10 x 10 meter on the edge of a slack in the dunes in the Flemish nature reserve Ter Yde/Hannecart/Kartuizerduinen (Oostduinkerke). In one half of this square, all plants are counted. In the other half, every orchid is located by measuring its position from two different fixed points. This method allows us to follow up the individual plants and to learn more about age, development, etc.

4.2 Biostatistics

In order to collect sufficient material for the statistical/biometrical part of the research, every year 14 individual *neerlandica* plants are measured, preferably the same. If a plant does not persist, a new individual plant is added to the sample, chosen at random. The following characteristics are measured:

- total height of the plant;
- distance between soil level and the first (true) leaf;
- number of leaves;
- length and width of the second leaf;
- length and width of the largest leaf;
- length of the inflorescence;
- number of flowers;
- length of the first (lowest) bract.

These criteria have already been used in other publications by Tyteca (1995) and Claessens *et al.* (1998). This will enable a comparison between the findings of this authors and our own.

The same procedure is followed for the collection of data from *Epipactis helleborine* plants. Plants are measured in my garden in Nieuwerkerken-Waas and on an artificially raised industrial plot in the Port of Antwerp.

4.3 Behaviour

In November 1999, some plants in the vicinity of the permanent square in Oostduinkerke were dug out and transferred to my garden, where they were planted nearby a hornbeam hedgerow (*Carpinus betulus*). At the same spot, a colony of

Epipactis helleborine had appeared spontaneously some years before. This is probably the most vulnerable part of the research. The transplantation of *neerlandica* plants from their natural habitat to a garden is not without risk. After a period of four flowering seasons, the surviving plants should be re-introduced into their original habitat. On the other hand, this part of the research is without any doubt the most interesting one and should reveal useful information regarding the taxonomical status of *neerlandica*. If the typical *neerlandica* habitus transforms into a *helleborine* habitus, the morphological differences are not genetically determined, but merely the result of ecological differences. This should then lead to the conclusion that *neerlandica* is not a species but a subspecies or a variety. If the habitus changes, the speed of that change can also learn more about the evolutionary status of *neerlandica*. If the change in habitus is a long term transformation (several seasons), we could conclude that the relationship of this taxon to *helleborine sensu stricto* is not so close.

5 Results

5.1 Population dynamics

In spring and early summer 2001 the dune slack was inundated for an unusually long period. This caused the death of more than 90% of the population in the entire region. Because of the presence of a ‘miniature dune’ with *Salix repens* within the permanent square some plants survived the inundation. It will be interesting to see how soon recolonisation will occur (see table 1).

Table 1. Number of plants in a permanent square in the dunes (Oostduinkerke).

year	flowering plants	non-flowering plants	total
1999	414	130	544
2000	363	88	451
2001	107	52	159

5.2 Biostatistics

In order to be able to separate the typical *Epipactis neerlandica* from *E. helleborine*, plants belonging to both taxa are measured. It is our intention to collect data from a hundred plants of both taxa. For 28 plants of each taxon, the results are presented in table 2.

Table 2. Comparison between *E. neerlandica* and *E. helleborine* (dimensions are given in millimetre)

	<i>Epipactis neerlandica</i> (n = 28)				<i>Epipactis helleborine</i> (n = 28)			
	MAX	MIN	MEAN	STDEV	MAX	MIN	MEAN	STDEV
Height plant	415	165	278	68	948	362	627	143
Soil to lowest leaf	47	1	17	12	205	38	98	39
Number of leaves	8	3	6	1	10	5	7	1
Length 2nd leaf	52	20	37	7	86	35	55	13
Width 2nd leaf	39	16	26	5	62	33	45	9
Length largest leaf	60	31	45	7	171	65	92	23
Width largest leaf	40	16	27	6	75	30	52	12
Length inflorescence	240	73	131	37	392	22	219	85
Number of flowers	46	13	27	9	79	18	42	17
Length of 1st bract	47	9	21	7	81	16	42	16

The data for *E. helleborine* come from a population in Antwerpen (Schouwkensstraat). The data for *E. neerlandica* come from the population in Oostduinkerke (Ter Yde). The plants used in the relocation experiment, are included in this sample.

We can already see that some criteria are very useful/reliable to distinguish *neerlandica* and *helleborine* plants from one another on a morphological base, such as height of the plant, length

and width of the largest leaf and length of the lowest bract. These results match those of Claessens, Kleynen & Wielinga (1998). With a statistical computer program they made a cusum analysis of their different sets of observations. This method allows to divide a number of observations in different groups/areas which differ significantly from one another. Their conclusion was that the total height of the plant and the length and width of the second leaf show significant differences.

At the end of our research period, more statistical analyses will be made to determine which characters are statistically significant to separate *helleborine* from *neerlandica*.

5.3 Behaviour

Until now, almost all transplanted *neerlandica* individuals have survived and kept their habitus. These plants are measured every year and are marked and followed as individual plants. Their flowering period has not changed: they bloom after *Epipactis helleborine* and so far, no possibility for hybridisation has occurred (see table 3).

It is not easy to comprehend the behaviour of the transplants. Sometimes plants do not flower and show only vegetative parts. Sometimes a deformation occurs during the development, which can lead to the abortion of (a part of) the flowering spike or leads to abnormal growth. Sometimes a plant goes dormant and skips a year above ground. That is the reason why we cannot show results of our measurings. The next years will probably be of vital importance for our study.

Plant 13 has not shown up in the garden. It is probably dead. All other plants appeared above ground during the first and/or second season.

Table 4 shows all appearances for the years 1999-2001.

Table 3. Comparison of some phenological observations of *E. helleborine* and *E. neerlandica*.

	<i>Epipactis helleborine</i>	<i>Epipactis neerlandica</i>
Shoots visible in 2000	First week of May	Third week of May
Beginning of flowering in 2000	10.07.2000	02.08.2000
Shoots visible in 2001	First week of May	Last week of May
Beginning of flowering in 2001	12.07.2001	28.07.2001

Table 4. Presence and status of the transplanted *E. neerlandica* per season. Fl+ = flowering; Fl- = deformed flowering spike; veg = shoot without flowers; X = not present above the ground; DF = deformed plant.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1999 <i>in situ</i> Oostduinkerke	Fl+	Fl+	Fl+	Fl+	Fl+	Fl+	Fl+	Fl+	Fl+	Fl+	Fl+	Fl+	Fl+	Fl+
2000 <i>ex situ</i> Garden season 1	Fl+	veg	Fl+	Fl-	veg	veg	Fl-	DF	Fl+	Fl+	Fl+	DF	X	X
2001 <i>ex situ</i> Garden season 2	Fl+	X	Fl+	Fl+	Fl+	veg	veg	Fl+	Fl+	X	Fl+	X	X	Fl+

6 Conclusions

After three years, it is too early for strong conclusions. If the following years confirm the present results, we may have to conclude that *Epipactis neerlandica* (Vermeulen) J. Devillers-Terschuren & P. Devillers is indeed best treated at species level. If on the other hand the following years show more changes in flowering time and habitus (as observed in 2002), we might have to conclude otherwise. During the evolutionary process, the morphological and ecological characteristics of a taxon become genetically fixed and thus it becomes isolated from related taxa. The degree of fixation justifies its taxonomical rank: species, subspecies, form or variety.

We hope that in the near future other aspects will become clear too, such as the patterns of behaviour, presence/absence of intermediate/transition/hybrid stage forms and the adaptation plasticity of '*neerlandica*' to the habitat it is confronted with.

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The specific diversity of Orchidaceae: an overview of contributions to the Belgian and European Floras over the 20th century

Daniel Tyteca

Centre de Recherche sur la Biodiversité, Université Catholique de Louvain
Rue Long Tienne 2, B-5580 Ave-et-Auffe; tyteca@poms.ucl.ac.be

Abstract. – Research on chorological and systematic aspects of Orchidaceae has developed extensively over the last few decades in Europe. In this communication some of the major trends are discussed and synthesized, and examples given more especially for Belgium. Significant systematic contributions were made using several tools, including morphological, morphometric, cytological, and more recently molecular approaches. This resulted both in a significant increase in the number of species currently recognised, either in absolute terms or in new territories, and in better classification frameworks, more especially in difficult genera such as *Ophrys*, *Dactylorhiza*, *Epipactis* and *Orchis*. Examples from the genera *Dactylorhiza* and *Epipactis* are discussed. In Belgium, the total number of Orchidaceae species recognised as indigenous has increased from 40 around 1970 to 47 today. This can be explained both by extensive field prospections, leading to discoveries of species previously not reported from our country, and by close analysis of critical genera using the methods listed above, resulting in the identification of several previously unknown taxa. Global trends in several territories, including the whole of Europe, show quite significant increase rates in the number of species, implying by extrapolation that the total number of species in the world might be much higher than currently recognized, reaching magnitudes of 50,000 or even 100,000. On the other hand, the rates of species extinction or regression are much harder to quantify but might be quite significant, due to human impacts, as exemplified again by the situation in Belgium, where extinction rates over the last forty years may be as high as 1.6 % per year.

Samenvatting. – De soortendiversiteit van Orchidaceae: een overzicht van bijdragen tot de Belgische en Europese Flora's gedurende de 20ste eeuw. Onderzoek naar verspreiding en systematiek van Orchidaceae heeft zich gedurende de laatste decennia sterk ontwikkeld in Europa. In deze bijdrage worden enkele belangrijke trends besproken en samengevat, en enkele voorbeelden uit België gegeven. Belangrijke bijdragen aan de systematiek werden gedaan vanuit verschillende benaderingen, waaronder morfologie, morfometrie, cytologie en meer recent molecular biologie. Dit resulteerde in een significante toename in het aantal erkende soorten, in absolute termen of in een bepaalde streek, en in betere classificaties, vooral in moeilijke genera zoals *Ophrys*, *Dactylorhiza*, *Epipactis* en *Orchis*. Voorbeelden uit de geslachten *Dactylorhiza* en *Epipactis* worden besproken. In België is het aantal erkende inheemse soorten Orchidaceae toegenomen van 40 rond 1970 tot 47 vandaag. Dit is zowel een gevolg van extensief veldwerk, dat geleid heeft tot

de ontdekking van voorheen niet van ons land gekende soorten, als van een grondige herziening van kritische genera met de hogervermelde methoden, resulterend in identificatie van verscheidene vroeger onbekende taxa. Algemene trends in meerdere streken, Europa inbegrepen, tonen een duidelijke toename in het soortenaantal. Dit impliceert, door extrapolatie, dat het totaal aantal soorten op wereldvlak veel groter zou kunnen zijn dan tot nog toe aangenomen en zich situeert rond 50 000, misschien zelfs 100 000. Anderzijds is de snelheid van uitsterven of achteruitgang veel moeilijker te bepalen, maar wellicht significant, door toedoen van de mens. De situatie in België kan als voorbeeld dienen: gedurende de laatste veertig jaar lag de snelheid van verdwijnen bij 1,6 % per jaar. Vertaald door de redactie.

Resumé. – *La diversité spécifique des Orchidaceae: un aperçu des contributions aux Flores de Belgique et d'Europe au cours du 20^{ième} siècle.* La recherche sur les aspects chorologiques et systématiques des Orchidaceae s'est considérablement développée dans les dernières décades en Europe. Dans cette communication, quelques-unes des tendances majeures sont discutées et synthétisées, et des exemples sont fournis spécialement pour la Belgique. Des contributions systématiques importantes ont été réalisées à l'aide d'outils divers, incluant les approches morphologique, morphométrique, cytologique, et, plus récemment, moléculaire. Il en est résulté à la fois une augmentation importante du nombre d'espèces reconnues, que ce soit en termes absolus ou dans de nouveaux territoires, et une meilleure classification, plus particulièrement dans des genres difficiles tels qu'Ophrys, Dactylorhiza, Epipactis et Orchis. Des exemples pris dans les genres Dactylorhiza et Epipactis sont commentés. En Belgique, le nombre d'espèces d'Orchidaceae indigènes reconnues est passé de 40 en 1970 à 47 aujourd'hui. Cet état de choses peut s'expliquer par l'intensification des recherches de terrain, menant à la découverte d'espèces non répertoriées auparavant dans notre territoire, et par l'analyse détaillée de genres critiques par le biais des méthodes évoquées plus haut, qui a abouti à l'identification de plusieurs taxons antérieurement inconnus. La tendance globale dans plusieurs régions, dont toute l'Europe, montre un taux significativement croissant du nombre d'espèces, impliquant par extrapolation que le nombre d'espèces total du Globe pourrait être bien plus élevé que celui qui est habituellement reconnu, atteignant des chiffres de 50 000 ou 100 000. D'un autre côté, les taux d'extinction ou de régression d'espèces sont nettement plus difficiles à quantifier mais pourraient être très importants, sous l'influence des activités humaines, comme le montre une fois de plus la situation en Belgique, où le taux d'extinction au cours des quarante dernières années a pu atteindre 1,6 % par an. Traduit par la rédaction.

Keywords: Orchidaceae, systematics, chorology, Belgium, Europe, diversity, extinction

Introduction: Orchid diversity in Belgium and other territories

Among the flowering plants (Angiospermae), the family Orchidaceae is one of the most diversified and the richest in species. Indeed, depending on the classification schemes and author conceptions, the total number of species ranges between 17000 and 35000; that is, approximately one species over ten among the Angiospermae is an Orchid (Dressler 1993; Pridgeon et al. 1999).

Even if representatives of the family are found almost all over the world, such a diversity is unequally distributed over the surface of the earth. For Orchids as for many other families of living beings, diversity is highest under tropical climates; tropical rainforests probably include the biotopes with highest diversity, while arctic areas host only a few species of Orchidaceae.

Diversity also depends on the conditions of the considered area as an inland or island territory. To give an idea, fig. 1 gives an account of Orchid diversity in several territories in the world, including islands, while fig. 2 gives a more particular picture of the situation among European and

Atlantic countries and islands. In both cases, the indicator used is the number of species divided by the logarithm (in base 10) of the corresponding area in km², which is supposed to give a fairer idea of diversity for comparison purposes. Indeed, using such a measurement unit allows for more appropriate scaling than using the absolute surface area (see, e.g., MacArthur & Wilson 1967).

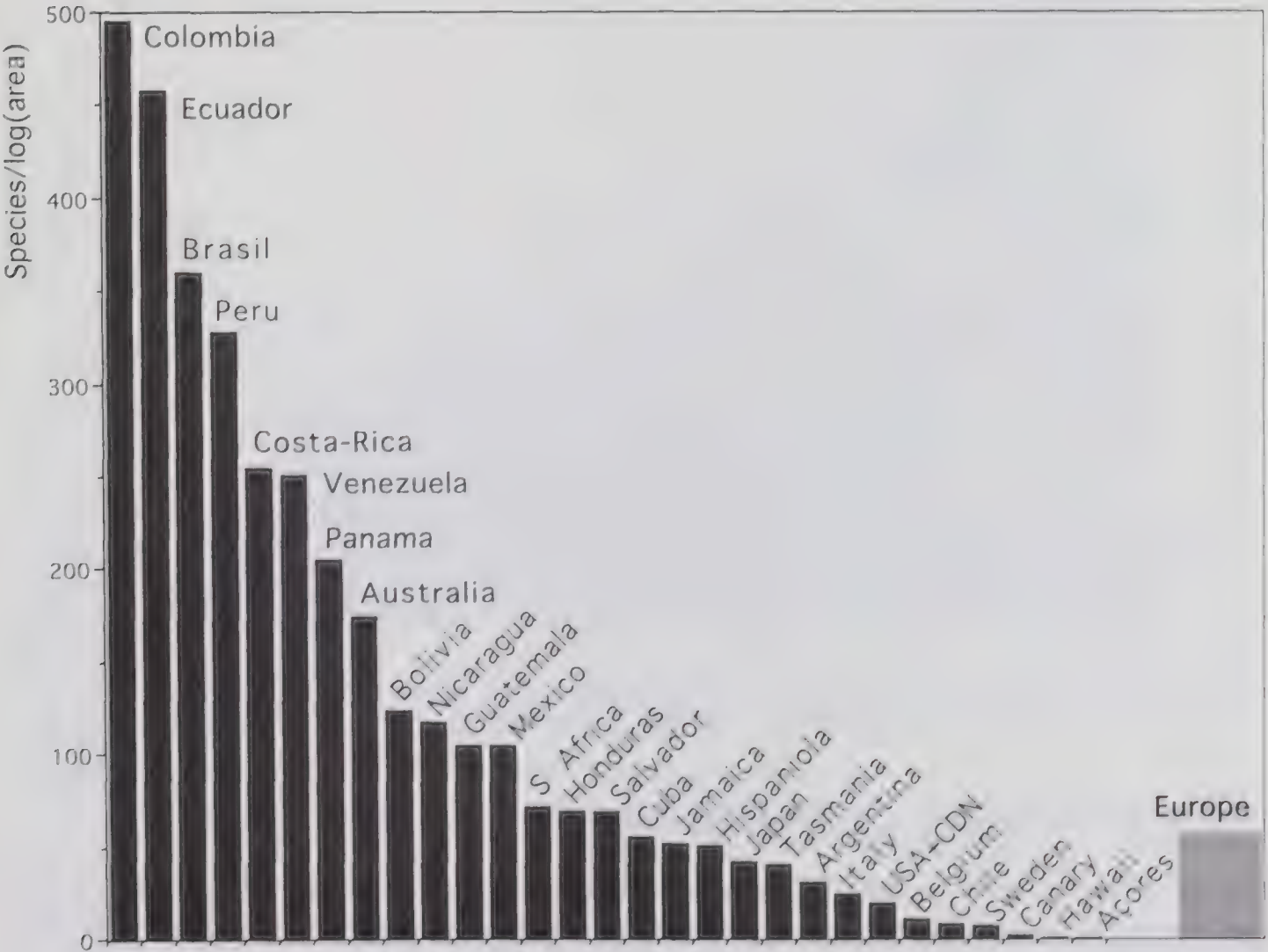


Figure 1. Diversity of Orchids in several territories of the world
(Data and sources: see Appendix 1).

The picture given in fig. 1 and 2 is consistent with several well-known facts, namely that (1) the closer the investigated territory is to the equator, the higher is the diversity; (2) conversely, the further north, the lower the diversity; (3) for islands, diversity decreases as an inverse function of the distance from the continent. Such facts have been observed for many classes of organisms (e.g., MacArthur & Wilson 1967); thus they also hold true for orchids (as developed in Tyteca 2002). Additional factors that influence diversity are the density of the human population and the geophysical characteristics of the territories, like climate, altitudinal range, geology, ecological diversity, etc, that are reflected in some of the situations depicted in fig. 1 and 2 (see, e.g., Tyteca 2002). On the other hand, there is some bias in those situations, due among others to the different periods of publication and the state and evolution of systematic standpoints, but generally speaking the comparisons yield results that are consistent with expectations. The evolution of systematic and chorological knowledge will be discussed in more detail in the following sections.

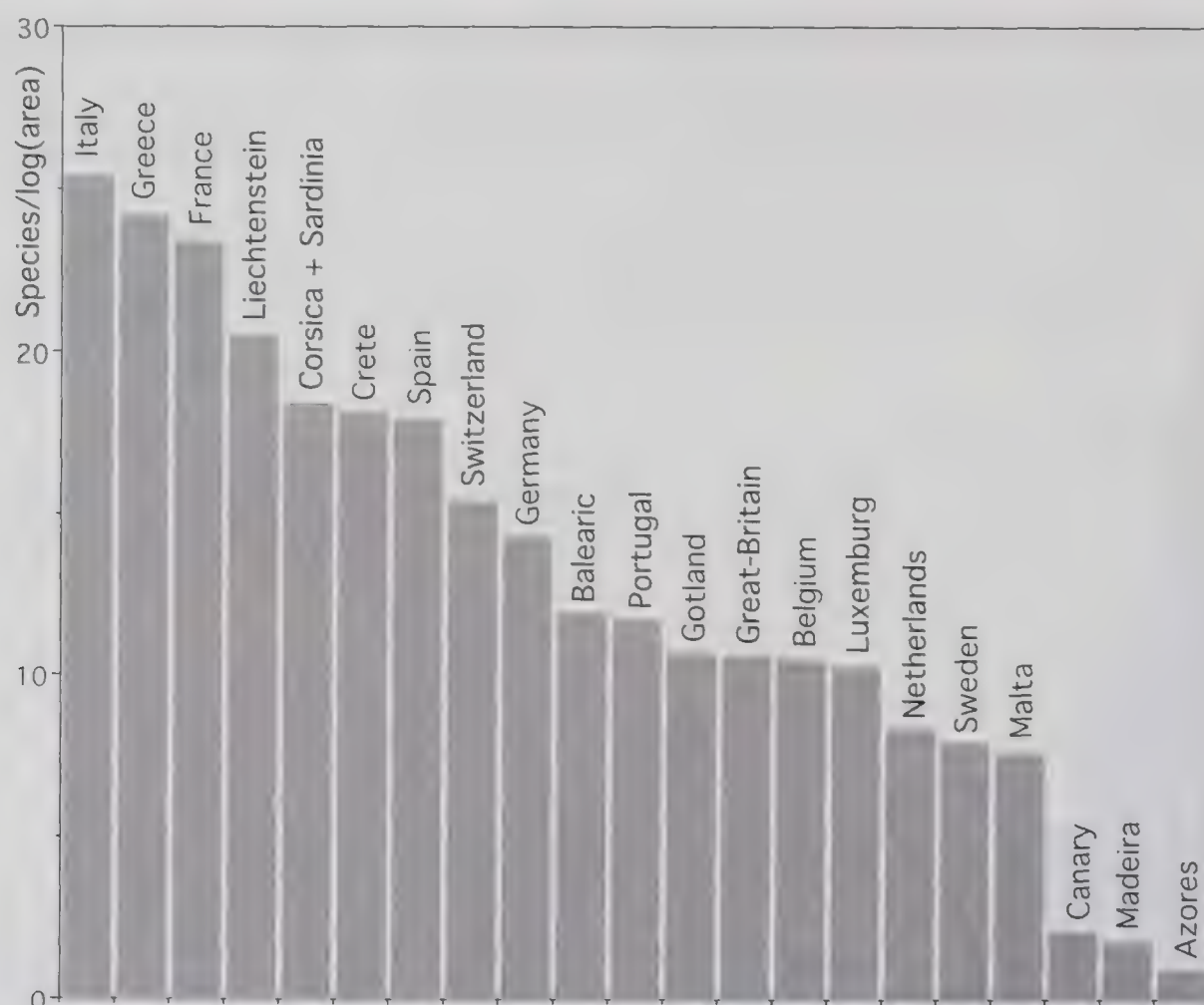


Figure 2. Diversity of Orchids in several territories of Europe and Atlantic islands
(Data and sources: see Appendix 1 – “National” territories are continental, excluding islands).

Methods used in the study of Orchidaceae and their impacts on knowledge

Orchids have been the subject of intensive research for a few decades. This has resulted in significant evolution in systematic and chorological standpoints. Broadly speaking, it can be said that those methods are the same as in many families of the living world. As it has often been the case, particularly in recent developments, those methods have not been used in isolation; instead, it has been realized that combinations of methods are more likely to bring better understanding about natural phenomena, and hence, about the way we organise and classify the families and genera of living beings. Some examples that resulted in significant contributions to the knowledge on Orchidaceae, especially in Europe, are listed below:

- Morphological analyses have been exploited for long. In recent developments, partly inspired by findings gathered from other investigation fields (see below), new standpoints have been proposed to classification schemes, especially in complex genera such as *Ophrys*, *Dactylorhiza* and *Epipactis*. In *Ophrys*, new sets of characters have proved to be useful to retrace phylogenetic relationships and to derive useful classification frameworks, such as the structure of the stigmatic area and the gynostemium, the arrangement and density of the lip pilosity, and the lip relief and gibbositities around the base. Recent examples of thorough studies based on extended sets of such characteristics are those by Devillers & Devillers-Terschuren (1994) or Delforge (2001). The same appears to be true for *Epipactis*, in which it turned out that important characters are the presence or absence of purple pigments on the ovary pedicel, the density of the stem pilosity, or the denticulation of the leave margins, as pointed out, e.g., by Gévaudan et al. (2001). These

characters have only scarcely been used until recently, although their usefulness had already been indicated, e.g., by Young (1949) or even botanists of the 19th century (see Gévaudan et al. 2001).

- As a complement to morphology, morphometrics or biostatistical methods have proved to be useful for a few decades, as an auxiliary to better understanding intra- or inter-population variability in difficult genera such as *Ophrys*, *Serapias*, *Nigritella* or *Dactylorhiza*. In the first of these genera, those methods have allowed for the identification and description of several new species, among other by Götz & Reinhard (e.g., 1980, 1982, 1989a, 1989b), while for *Dactylorhiza*, new species and new taxonomical ranks have been proposed through use of similar methods, for example, by the author and collaborators (for an account of the methods, see, e.g., Gathoye & Tyteca 1987; Tyteca & Gathoye 1989; Dufrêne et al. 1991; Tyteca & Dufrêne 1993, 1994). The recourse to such methodologies often allows for substantiation of previously intuitive standpoints, as has been the case, e.g., for *Dactylorhiza parvimajalis* or *D. savogiensis*, two species recently described by those authors (Tyteca & Gathoye 1990, 2000). It should be emphasized, however, that the sole recourse to biostatistical methods cannot be effected in isolation from other perspectives, as stressed by Tyteca (2001a).
- Cytology has for long been used to clarify the relationships among important genera, such as, for example, *Dactylorhiza* (e.g., Averyanov 1990; Gathoye & Tyteca 1989) or *Orchis* (e.g., Pridgeon et al. 2001). The information to be accounted for, in those studies, is essentially the chromosome number, which has proved to be useful in some genera such as those cited, but appears to be of only little help in more homogeneous genera such as *Ophrys*.
- Quite recently, molecular analysis methods have proved to be useful to clarify the phylogenetic relationships between and among genera of Orchidaceae, and shed new light on systematic standpoints; as such, they appear more and more as necessary complements to other investigation methods. Significant contributions and changes have been proposed, as described, e.g., by Pridgeon et al. (1997, 1999) or Bateman (2001) for Orchidaceae in general, and by Hedrén (1996a, b, c) for the genus *Dactylorhiza*. In the former examples, essentially systematic classification and distribution of species among genera have been affected, while in the latter examples, the allo- and auto-tetraploid origin of certain *Dactylorhiza* species has been proved.
- Studies on pollinators have brought about significant and useful information, mainly in the genus *Ophrys*. The observation of the close bilateral relationships between species of *Ophrys* and Insecta Hymenoptera have allowed researchers to propose the designation of several new species (e.g., Paulus & Gack 1990; Paulus 1998, 2001).
- Finally, in complement to all of the aforementioned methods, it cannot be stressed enough that we also need to take into consideration field methods, including studies on population ecology, and chorological research, to better understand the geographical and ecological patterns of species distribution. In this perspective, a factor that should also be emphasized is the improvement and generalization of photographic techniques, which often gave rise to identification of critical and/or remarkable situations.

As consequences of the isolate or combined use of those methods, significant contributions to the knowledge on Orchidaceae, especially in Europe, have been made possible in such areas as (1) species distribution, including the identification of previously described species in new territories, (2) classification of species within and among genera, (3) the overall diversity as reflected by the number of recognized species. Two examples will be given below, regarding *Epipactis* and *Dactylorhiza* in Belgium, while the next section will consider the evolution of orchid diversity in different European territories in a more general way.

Let us consider the genus *Epipactis* first. Only three species were widely known in Belgium until the first half of the 20th century, namely, *E. helleborine*, *E. atrorubens* and *E. palustris*. It is not before 1953 that new species were added to the indigenous flora, and since then, no less than seven additional species have been successively incorporated, as table 1 indicates. It can be said

that such additions, in Belgium, mainly came from close morphological examination, with consideration of ecological characteristics and extensive field studies.

Table 1. List of *Epipactis* species recognized as indigenous in Belgium, with indication of the first mention in the country.
Nomenclature according to Lambinon et al. (1993), except for *E. neglecta* (Kümpel) Kümpel and *E. neerlandica* (Vermeulen) Devillers-Terschuren & Devillers.

Species	First mention in Belgium
<i>E. helleborine</i>	(before 20 th century)
<i>E. atrorubens</i>	(before 20 th century)
<i>E. palustris</i>	(before 20 th century)
<i>E. purpurata</i>	1953 (Lawalrée 1956)
<i>E. microphylla</i>	Young (1958)
<i>E. muelleri</i>	Young (1958)
<i>E. leptochila</i>	Terschuren & Devillers (1981)
<i>E. phyllanthes</i>	Chaumont (1984)
<i>E. neerlandica</i>	1987 (Devillers-Terschuren & Devillers in Coulon 1989)
<i>E. neglecta</i>	Devillers & Devillers-Terschuren (1999)

Approximately the same comments apply to the genus *Dactylorhiza*, giving the results indicated in table 2. However, in this case, in addition to morphological, ecological and field studies, morphometric and cytological analyses in a wider European context also came into play to provide for additional explanation and clarification of systematic standpoints. This is even more the case if we consider the increase in species numbers in Europe as a whole or in many European countries in particular. To illustrate this, fig. 3 gives the evolution in France and Europe, based on figures collected in several works of the 20th century (Tyteca 2001a). It can be seen that, despite significant deviations in taxonomy due to the different conceptions of ‘splitters’ and ‘lumpers’, there is an overall trend towards an increase in the number of recognized species. If we accept the regression coefficients given in fig. 3, presently there is an average trend towards recognition of one new (sub-) species every two years in Europe and every five years in France, approximately. Such rates are even more pronounced if we consider the case of the genus *Ophrys*, in which it can be roughly estimated that ten to twenty species are newly described every year, making this genus, by far, the richest in species among European Orchidaceae.

Table 2. List of *Dactylorhiza* (sub-)species recognised as indigeneous in Belgium, with indication of the first mention in our country (nomenclature according to Lambinon et al. 1993).

(Sub-) species	First mention in Belgium
<i>D. maculata</i>	(before 20 th century)
<i>D. majalis</i>	(before 20 th century)
<i>D. incarnata</i>	(before 20 th century)
<i>D. maculata</i> subsp. <i>elodes</i>	1916 (Lawalrée & Vanden Berghen 1946)
<i>D. praetermissa</i>	Houzeau de Lehaie (1929)
<i>D. fuchsii</i>	at least 1967 in Mullenders et al. (1967)
<i>D. praetermissa</i> subsp. <i>integrata</i>	Petit (1980)
<i>D. sphagnicola</i>	1980 (Tyteca 1981; Coulon 1981; Terschuren & Devillers 1981)
<i>D. maculata</i> subsp. <i>ericetorum</i>	Devillers-Terschuren & Devillers (1986)

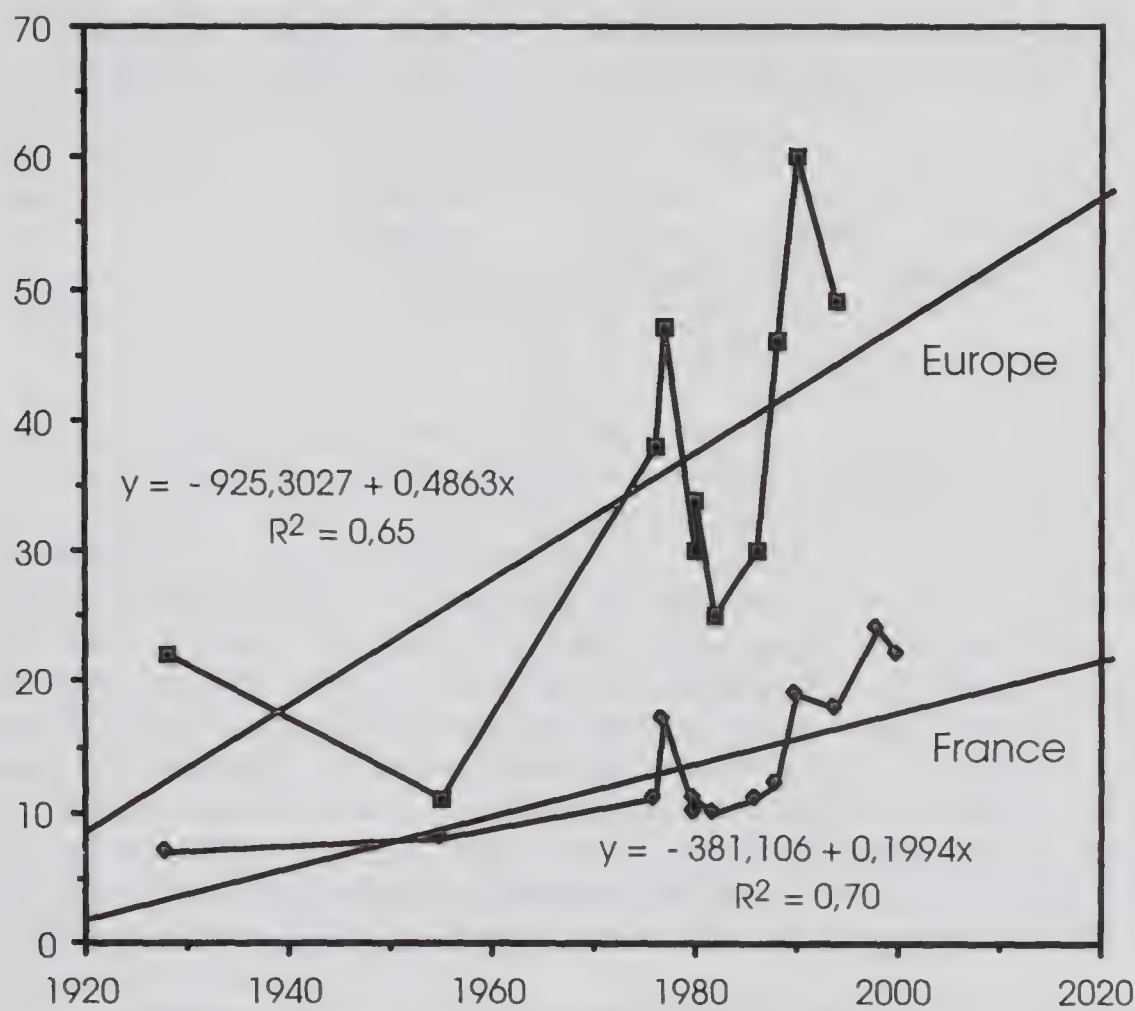


Figure 3. Evolution of the number of *Dactylorhiza* (sub-) species in Europe and in France during the 20th century. Detailed figures are given in Appendix 2.

Evolution of diversity in various territories

Taking a larger perspective now, we can try to give an account of the evolution in systematic and chorological knowledge of the whole Orchidaceae family, and this for Belgium, Europe and a few other European countries. This has been attempted in table 3 for the last twenty years, a period for which the evolution in several territories is well documented. Significant trends can be perceived, differing among the territories considered. In Belgium, the situation was not likely to move considerably because it has been a well prospected area for a number of years, although there has been some progress, mainly for the genera *Epipactis* and *Dactylorhiza*, as described in the previous section. The trend given in table 3 can even be extrapolated back to 1967; at that period, approximately 40 species were known in Belgium (Mullenders et al. 1967). In countries such as France and Portugal, the increase is more sensible, due to incomplete knowledge and prospections in previous decades, and also due to the more diversified biotopes, as well as altitudinal and climatic conditions. In addition, other genera come into play, such as *Ophrys*, *Serapias*, *Orchis* or *Nigritella*, thus yielding even more pronounced increase trends. Looking at the situation for the whole European territory, the trend is still stronger, largely due to the description of many new species in the genus *Ophrys*, as mentioned above. It is important to point out here that the increase in species numbers in small continental territories like Belgium or Portugal seldomly comes from description of new taxa (i.e., such an increase mainly originates from discovery of previously described taxa in new territories), while this is less and less the case as the size of the investigated territory increases. As a result, for the whole of Europe, the figures of table 3 mostly correspond to newly described taxa.

Table 3. Evolution in the number of recognized species of Orchidaceae for four European territories over the last twenty years (sources: for Belgium, Tyteca 1983, 1986, 2001c; for France, Jacquet 1983, 1988, 1995, 1997, 2000; for Portugal, Tyteca & Tyteca 1986; Tyteca 1998, 2001b; for Europe, Baumann & Künkele 1982; Delforge 1994, 2001).

Territory	Number of species (year)			Average trend
Belgium	43 (1983)	45 (1986)	47 (2001)	0.5 %/year
Portugal	47 (1986)	55 (1997)	58 (2001)	1.6 %/year
France	97 (1983)	107 (1988)	144 (1995) 162 (2000)	3.9 %/year
Europe	160 (1982)	300(1994)	400 (2001)	7.9 %/year

The figures given in table 3 allow to produce the illustration of fig. 4, showing the total increases observed for each of the four territories since the first year of observation. This amounts to 9.3 % over 18 years in Belgium (or 17.5 % over 34 years), 23.4 % over 15 years in Portugal, 67 % over 17 years in France, and 150 % over 19 years in Europe. Such dramatic increases, especially in the latter two cases, may lead, by extrapolation, to reconsider the total number of Orchids currently identified and listed all over the world. If a trend such as the one identified in Europe is truly consistent, and representative of the situation in the world, and speculating about the even more diversified situations and incomplete prospections in other continents, one might expect that the number of Orchid species over the planet might rise to figures of the magnitude of 50,000 or even 100,000. And indeed, in a territory such as Australia, the number of known species, which amounted to approximately 800 in 1989 (Clements 1989), is now estimated to be above 1200 (Jones et al. 1999; D.L. Jones, personal communication), thus yielding an increase rate of 5 % per year over the last ten years, thus approaching the rates recorded for France or Europe.

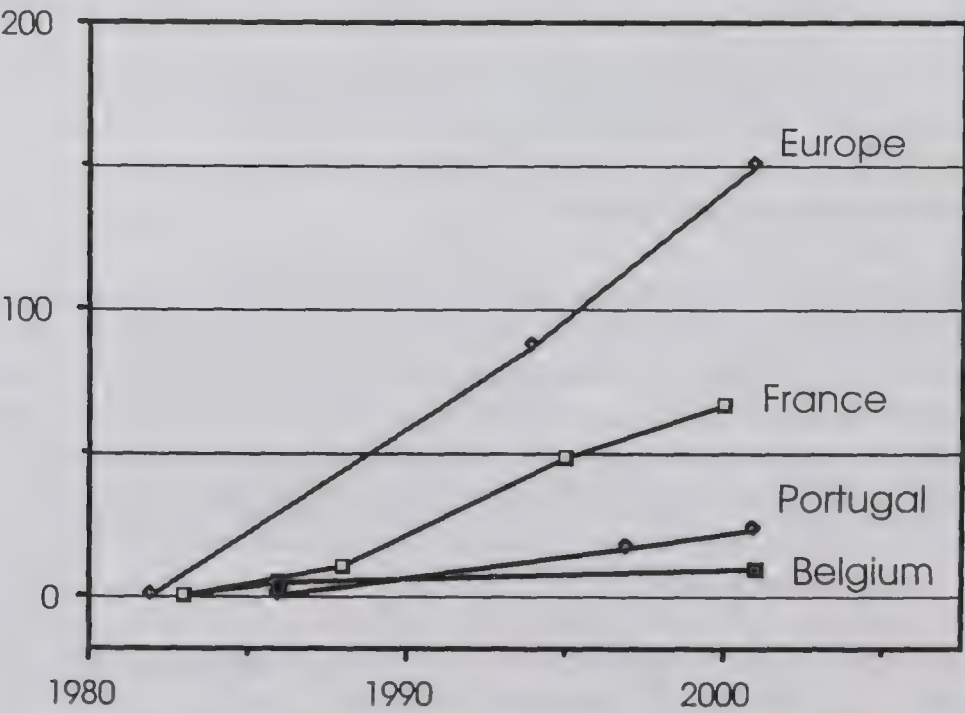


Figure 4. Evolution of Orchid diversity in four territories over the last twenty years, as a percentage of the initial situation (based on data from table 3).

Concluding remarks: increased knowledge vs. species extinction

The euphoric description and recognition rates described in the previous section must not let us forget that there are also many reasons for concern, in the case of Orchidaceae as well as in other families. Mainly because of habitat destruction, reduction and isolation, and other anthropic

reasons such as climate change, pollution or changes in agricultural practices, many Orchids are under heavy threat in most parts of the world. Probably we have not yet reached the point where the documented rate of extinction or regression becomes higher than the rate of discovery due to continuous, thorough studies with the methods discussed in the previous sections. Yet it is quite certain that the net rate of evolution in the number of species is negative, because the newly described taxa were already existing before they were identified, while there are documented situations of extinction, as we will see now through a brief overview of the Belgian situation.

The studies by Lawalrée & Delvosalle (1969) and Tyteca (1983) give information about several species of Orchidaceae. It is almost certain that *Cypripedium calceolus*, *Pseudorchis albida*, *Orchis laxiflora*, *O. coriophora* and *Spiranthes aestivalis* became extinct in Belgium around or before 1862, 1939, 1941, 1946 and 1955, respectively. *Orchis palustris* most probably disappeared around or before 1960 (L. Vanhecke in Tyteca 1986). For at least one species, *Cephalanthera rubra*, recorded data are very scarce and it is still unsure whether this species, due to its ephemeral behaviour, still persists in Belgium. Due to extensive field prospections, two species that were thought to be extinct were rediscovered in recent years, namely *Corallorhiza trifida* in 1978 (van Tooren 1981) and *Spiranthes spiralis* around 1995 (Bournérias et al. 1998). However, the situation of the latter, as well as that of *Liparis loeselii* and *Ophrys sphegodes* are quite critical and these species are presently highly endangered. The situation of other species is very critical, due to very few populations and/or small numbers of individuals in existing populations. Such is the case for at least *Herminium monorchis*, *Coeloglossum viride*, *Epipactis microphylla*, *E. leptochila*, *Gymnadenia odoratissima*, *Hammarbya paludosa*, *Orchis morio* and *O. ustulata* (see, e.g., Delforge 1998a, b; Devillers et al. 2001; Tyteca et al. 2001). Some species still well represented in Belgium presently undergo dramatic reductions in their numbers, like *Goodyera repens* (Devillers et al. 2001).

Trying to quantify the rate of extinction in Belgium, these data can be used to perform the following rough calculation. Of the probable 52 species that existed around 1940 or before (the 47 indicated in table 3, plus five listed above - thus excluding *Cypripedium calceolus* which has disappeared since much longer), five most probably disappeared, while the exact moment of their extinction is uncertain. If we admit that part of these species might have become extinct even recently, we come to an extinction rate of $5/52 = 9.6\%$ over ± 60 years, i.e., a rate of 1.6% per decade, or one species (over 52) lost every twelve years. This is still much lower than the discovery rates enumerated in table 3, even for Belgium, and it is even more difficult to quantify extinction rates in other territories. The obtained rate of 1.6% per decade, even if it was obtained for the Belgian territory taken isolately, is of the same magnitude as other estimations of extinction rates among living beings (e.g. Barbier et al. 1994). It can be said that such extinction rates are good indicators of the unsustainability of present human practices and habits, while we are still far from the situation where such dramatic trends will be reverted.

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Appendix 1. Data and sources used for the indicators of diversity used in fig. 1 and 2.

World			
Country	Surface (km ²)	N. of species	Nspec/log ₁₀ (surf)
Colombia	1138914	3000	495,376
Ecuador	283561	2500	458,463
Brasil	8511965	2500	360,750
Peru	1285216	2000	327,386
Costa-Rica	50700	1200	255,048
Venezuela	912050	1500	251,678
Panama	75650	1000	204,960
Australia	7686848	1200	174,267
Bolivia	1098581	750	124,152
Nicaragua	130000	600	117,325
Guatemala	108889	530	105,221
Mexico	1972547	660	104,845
S Africa	2693420	458	71,229
Honduras	112088	350	69,307
Salvador	21393	300	69,284
Cuba	114524	280	55,347
Jamaica	10962	210	51,980
Hispaniola	76484	250	51,188
Japan	372313	234	42,003
Tasmania	67230	195	40,389
Argentina	2776889	200	31,037
Italy	251427	137	25,370
USA+ Canada	19187592	140	19,223
Belgium	30513	47	10,481
Chile	756945	50	8,505
Sweden	446963	45	7,965
Canary	7273	8	2,071
Hawaii	16600	6	1,422
Açores	2335	3	0,891
Europe	10531623	400	56,964

Sources: Latin American countries, Dressler 1981; North-America and Hawaii, Correll 1950; Luer 1975; Australia and Tasmania: Clements 1989; Jones et al. 1999; South-Africa, Linder & Kurzweil 1999; Japan, Hashimoto et al. 1991.

Europe and Atlantic islands

Country/island	Area (km ²)	N. of species	Nspec/log ₁₀ (area)
Italy	251427	137	25,370
Greece	113808	122	24,130
France	538346	134	23,382
Liechtenstein	160	45	20,417
Corsica/Sardinia	32770	83	18,383
Crete	8336	71	18,108
Spain	497500	102	17,904
Switzerland	41288	71	15,381
Germany	356789	79	14,229
Balearic islands	5014	44	11,892
Portugal	89007	58	11,720
Gotland	3001	37	10,641
Great-Britain	227980	57	10,638
Belgium	30513	47	10,481
Luxemburg	2586	35	10,255
Netherlands	33491	38	8,398
Sweden	446963	45	7,965
Malta	316	19	7,600
Canary islands	7273	8	2,071
Madeira	740	5	1,743
Azores	2335	3	0,891

Sources: mostly Delforge 1994; additional data: France and Corsica: Jacquet 1995; Liechtenstein: Rheinberger et al. 1991; Balearic: Alomar 1994; Portugal: Tyteca 1998, 2000, 2001b; Belgium: Tyteca 1983, 1986; Luxemburg: Mangen et al. 1993; Sweden and Gotland: Hansson 1992; Madeira: Rückbrodt & Rückbrodt 1990; Azores: Rückbrodt & Rückbrodt 1994.

Appendix 2. *Dactylorhiza* species: Data and sources used in fig. 3 (from Tyteca 2001a; numbers between brackets indicate species not explicitly enumerated for France).

Author(s)	Year	Species recognised	
		in Europe	in France
Keller & Schlechter	1928	22	(7)
Duperrex & Dougoud	1955	11	8
Nelson	1976	38	11
Landwehr	1977	47	17
Sundermann	1980	30	10
Flora Europaea (Soó)	1980	34	11
Baumann & Künkele	1982	25	10
Buttler	1986	30	11
Baumann & Künkele	1988	46	(12)
Jacquet	1988	-	12
Averyanov	1990	60	(19)
Delforge	1994	49	18
Jacquet	1995/2000	-	22
Bournérias et al.	1998	-	24



The botanical biodiversity of Belgium: how many species are there? Problems and conclusions from a questionnaire

Guido Rappé

National Botanic Garden of Belgium, Domein van Bouchout, B-1860 Meise, Belgium
guido.rappe@br.fgov.be

"With the destruction of each component of wild life one more piece of evidence for human ignorance is removed."

Stephan Helfer

"If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering."

Aldo Leopold

Abstract. – In order to prepare the national monograph on Belgian biodiversity, BIODIV sent out a questionnaire to experts to gather information on the state of the art of 'botanical' taxa in Belgium. The full results of the botanical work have recently been published in the report "Biodiversity in Belgium" (Rappé & Rammeloo 2003), together with a.o. the information on fauna and ecosystems. The present paper gives some background information on how the results were achieved. Many problems had to be tackled: taxonomical delimitation, insufficient, unequal or lacking responses, outdated information, literature search, problems on valid species and synonymy with highly disparate views among specialists,... In the table a total of 53 'taxonomical' groupings have been recognized on Belgian territory. Only few groups are well known (checklist and/or Flora available): vascular plants, bryophytes, charophytes s.s., marine benthic macro-algae, macrofungi, lichens and Laboulbeniales. The remaining are moderately to poorly known. Including the photo-autotrophic prokaryotes (but excluding the archaea and the other bacteria) the observed Belgian 'botanical biodiversity' has been estimated to lie between 13,000 and 13,800 species, with an additional one third to one fifth of the real number of species still to be discovered. The Belgian flora comprises about 3-4% of the known global 'botanical' species total, estimated here at 386,000 (392,000 all prokaryotes included). It has been concluded that the knowledge of biodiversity is fragmentary and a lot of work still needs to be done, especially on microorganisms from soil and marine environments, and on parasitic and pathogenic agents from non-commercial host organisms: bacteria, archaea, marine (pico)phytoplankton, marine "fungi", zygomycetes, glomeromycetes and other microfungi or pseudofungi (slime moulds, alveolates, heterokonts).

Samenvatting. – De botanische biodiversiteit van België: hoeveel soorten zijn er? Problemen en bevindingen naar aanleiding van een enquête. Ter voorbereiding van de nationale monografie omtrent de Belgische biodiversiteit, heeft BIODIV een vragenlijst rondgestuurd aan specialisten om informatie te verzamelen omtrent de toestand van de kennis van de ‘botanische’ taxa aanwezig in ons land. De volledige resultaten van het botanisch deel werden recent gepubliceerd in het rapport “Biodiversity in Belgium” (Rappé & Rammeloo 2003), samen met o.a. de informatie omtrent de aanwezige fauna en de ecosystemen. Onderstaande bijdrage geeft enige achtergrondinformatie over het geleverde werk en de vele problemen die opdaagden: taxonomische omschrijving, onvolledige, ongelijkmatige of helemaal geen antwoorden, verouderde informatie, literatuuronderzoek, problemen rond geldige soorten en synonymie, waarbij de meningen van de specialisten ver uiteenlopen,... In de tabel worden 53 ‘taxonomische’ groepen opgenomen die zijn aangetroffen op Belgisch grondgebied. Slechts enkele ervan kunnen we beschouwen als goed gekend (een soortenlijst of Flora voorhanden): vaatplanten, mosplanten, echte kranswieren, benthische macro-zeewieren, macrofungi, korstmossen en Laboulbeniales. De overige zijn matig tot slecht gekend. De foto-autotrofe prokaryoten (blauwwieren) inbegrepen (maar zonder de overige prokaryoten) wordt de Belgische ‘botanische biodiversiteit’ geraamd op tussen de 13000 en 13800 waargenomen soorten. Er wachten bovendien naar schatting nog een derde tot een vijfde van het werkelijke aantal op ontdekking. De Belgische flora omvat zo’n 3-4% van het wereldwijd totaal aantal gekende ‘botanische’ soorten, dat hier geschat wordt op 386000 (392000 inclusief alle prokaryoten). Het belangrijkste besluit is dat de kennis van de biodiversiteit nog fragmentair is en er nog veel werk dient te gebeuren, vooral betreffende bodemorganismen, mariene micro-organismen en parasitaire en pathogene organismen van niet-commerciële gastheren: bacteriën, archaea, marien (pico)phytoplankton, mariene “fungi”, zygomyceten, glomeromyceten en andere microfungi of pseudofungi (slijmzwammen, alveolaten, heterokonten).

Résumé. – La biodiversité botanique en Belgique: combien d’espèces y a-t-il? Problèmes et conclusions lors d’une enquête. Afin de préparer la monographie nationale sur la biodiversité en Belgique, BIODIV a envoyé un questionnaire pour rassembler l’information concernant la situation du travail des taxons botaniques en Belgique. Les résultats complets du travail botanique ont été publiés récemment dans le rapport “Biodiversity in Belgium” (Rappé & Rammeloo 2003) avec l’information sur e.a. la faune et les écosystèmes. Ce texte donne quelques informations de fond sur la manière dont ces résultats ont été obtenus. De nombreux problèmes ont dû être abordés: délimitation taxonomique, réponses insuffisantes, inégales ou manquantes, information périmée, recherche dans la littérature, problèmes de validité d’espèces et de synonymie avec des points de vue très disparates des spécialistes... Dans le tableau un total de 53 groupements “taxonomiques” est reconnu sur le territoire belge. Seuls quelques groupes sont bien connus (checklist et/ou Flore disponibles): plantes vasculaires, bryophytes, charophytes s.s., macroalgues marines benthiques, macrofungi, lichens et laboulbéniales. Le reste est moyennement ou peu connu. Si l’on inclut les procaryotes photosynthétiques (excluant les autres), la biodiversité en Belgique est estimée à 13000-13800 espèces observées, avec un tiers à un cinquième du nombre réel d’espèces qui sont encore à découvrir. La flore belge comprend 3-4 % du nombre total d’espèces connues, estimé ici à 386.000 (392.000 incluant tous les procaryotes). La conclusion en est que la connaissance de la biodiversité demeure fragmentaire et qu’un énorme travail reste à faire, surtout sur les microorganismes du sol et des milieux marins et sur les parasites et agents pathogènes d’hôtes non commercialisés: bactéries, archéobactéries, (pico)phytoplankton marin, “fungi” marins, zygomycètes, glomérormycètes et d’autres microfungi ou pseudofungi (myxomycètes, alvéolés, hétérokontes).

Keywords: Belgium, biodiversity, flora, species number

Abbreviations: CBD, Convention on Biological Diversity

1 Introduction

The Convention on Biological Diversity (CBD) was presented during the UN Earth Summit in Rio de Janeiro in June 1992, and signed at the time by 156 countries and the European Union, representing almost every country and government of the world. It was drawn in the same spirit of awareness as Agenda 21, a globally endorsed framework for the 21st century, addressing the combined issues of environmental concern and fair and equitable development for all. Conceptions such as ‘wise use’, the ‘precautionary principle’ and ‘sustainable development’ were born or reached maturity. One of the major concerns in Agenda 21, and the subject of the Convention, are the many severe threats posed on the life forms of planet Earth, its biosphere. The total diversity of life forms on Earth and their natural relationships is also designated with ‘biological diversity’ or ‘biodiversity’.

From archebacteria in hot springs, symbiotic bacteria and ciliates in the intestines of ruminants and termites, coccolithophorids that build huge marine deposits and are responsible for the white cliffs of Dover, the lichens on the roof of your house or garden shed, the sea food on your plate, that annoying mosquito or fluttering butterfly, poisonous tree frogs in the Amazon forest, the komodo dragon, the blackbird singing in the backyard, a lonely seedling of sea kale on the beach, to the awesome great white shark and the ‘never-ending’ surfacing blue whale, all this is biodiversity.

The biodiversity in our close surroundings is not always as spectacular as the nature documentaries on television show. Nevertheless it is worth studying and protecting, for its intrinsic value and for its present and future value to humankind.

To be able to take appropriate measures to safeguard these natural treasures, one needs to know who the biological players are in a given geographical area. The biodiversity of a small, developed country like Belgium may at first sight be extensively studied and well known. Indeed we know what birds are breeding here or passing on migration. We know what wild flowers we can expect to encounter in a particular landscape or habitat. We know which frogs have become rare, which bats are doing well and which butterflies have become locally extinct. The biodiversity however also comprises the many microscopic bacteria, algae and moulds, plant and animal pathogens, the thousands of insects,... many of which being poorly known. Often the knowledge is fragmentary, scattered over many literature sources, collections or in the heads of experts. To bring together the existing information on the biodiversity of Belgium, the Inter-ministerial Conference for the Environment decided to prepare a monograph. The faunal biodiversity was treated by some of our colleagues from the Royal Belgian Institute of Natural Sciences, who also acted as coordinators. For the traditionally ‘botanical’ taxa the National Botanic Garden of Belgium (NBGB) was engaged. This assignment was then confined to the biodiversity initiative BIODIV, that is housed in the NBGB.

At the time of the symposium BBB 2001, only preliminary results were presented, but the work has continued. The full results have recently been published in the report “Biodiversity in Belgium” [Rappé & Rammeloo 2003, in Peeters & al. (eds)], further referred to as the ‘national monograph’, and will not be repeated here. These include a state of the art of the knowledge on each of the botanical (and other) taxa present in Belgium, together with references and further reading.

In the present contribution the reader will find anecdotal background information on the methodology used, some of the problems encountered, a summary table of the results (slightly differing from the one presented in the national monograph) and the preliminary conclusions of the Sisyphean job to be done to answer this very straightforward, popular and seemingly simple question: “how many species are there?”

For the record, the discussion on the number of species recorded and expected in Belgium and the global species number of the taxa focuses on the known diversity, i.e. the described species.

We do not venture into the tricky question “How many extant species does the earth really have?” Others have tried to find answers to it, with various results (e.g. Hawksworth & Kalin-Arroyo 1995).

This is the first time since the turn of the 19th century (see De Wildeman & Durand 1898-1907 with the ‘Prodrome de la flore belge’) that such an exercise has been executed in Belgium.

2 Methodology

Botany has been used here in its classical sense (see Preface), including the prokaryotes. The botanical chapter includes information on bacteria, algae (including the prokaryotic blue-green algae), green plants and fungi. A questionnaire was edited by the author, largely based on the model used for the zoological experts and developed by M. Peeters & J. Van Goethem of the Royal Belgian Institute of Natural Sciences on the basis of a model created by Krikken and Koomen (Naturalis, Leiden, the Netherlands). The approach used has been basically the same throughout the whole national monograph, but differs in details for the botanical part.

It consisted of two forms, the first one with a list of required basic questions, the second one dealing with more advanced items. The former comprised a total of 23 questions, grouped around 7 main topics: observed species number in Belgium, state of taxonomical and botanical knowledge, trends, species richness in general and in a geographical and an ecological perspective, and literature. The latter, optional form was much shorter, 8 questions in total, and focused on alien species and the population level. The questionnaire was made available in Dutch, French and English. It was then sent by the National Botanic Garden to the best Belgian experts in the appropriate taxonomical group(s). The answers of the completed forms were ‘translated’ into a summary text by the author (Rappé & Rammeloo op.cit.). The correspondents are acknowledged in the respective texts (for a full list see at the end of the present contribution).

3 Problems

Before being able to draw the texts for the national monograph, a number of practical problems had to be tackled.

3.1 Taxonomic delimitation

Life used to be simple. There were animals and plants, zoology and botany, zoologists and botanists. The latter studied bacteria, mushrooms, algae, bryophytes, pteridophytes and spermatophytes. Relatively ‘new’ taxonomical concepts (alveolates, heterokonts, streptophytes) have finally found their way to the general textbooks (e.g. Raven et al. 1999, 2000; Graham & Wilcox 2000; Sitte et al. 2002; Asperges et al. 2002). That ‘green algae’ are divided over two divisions, representing two major evolutionary lineages, one of which including the embryophytes, is finally ‘getting through’. Along the process the definition of ‘plant’ has shifted to various degree, as illustrated in a recent major handbook on Algae (Graham & Wilcox 2000), where ‘plants’ are synonymized with ‘landplants’.

The delimitation, within the context of Belgian botanical biodiversity, of the many ‘taxonomic’ paragraphs has been dictated by multiple factors such as systematics, common scientific practice and the particular Belgian expertise. This explains why flowering plants have not been subdivided any further while chlorophytes have been subdivided here in a pragmatic manner, the Belgian scholars being split in a non-taxonomic way: marine versus continental workers. Laboulbeniales on the contrary, a highly specialized order of ascomycetes, have been treated separately. This may seem an eclectic point of view, but offers the opportunity to illustrate the highly diverse degrees of

knowledge in the matter, as we are lucky to have a specialist in Belgium. Also, though we have tried to follow present day insights in phylogeny and systematics as much as possible, the following presentation of the results should not be read as a course in systematics. There are many fine handbooks and papers going into details for the reader who feels the need (see above). In one case in particular we have opted not to follow the formal hierarchic ranks and their appropriate suffixes imposed by systematics and the International Code of Botanical Nomenclature. Following some present day (mainly cladistic) phylogeny insights consequently, one would end up with too many intermediate levels (with less commonly known suffixes) before arriving at the angiosperms. For all groups of land plants (embryophytes) we have kept the suffix –ophyta at all distinguished levels in the original text (Rappé & Rammeloo op.cit.), strengthened by the practice in some influential handbooks (e.g. Raven et al. 1999). Sitte et al. (op.cit.) offer an honorable alternative, which is more or less followed in table 1. In fact the choice on the use of higher ranks in taxonomy is left open to the user. The order in which the embryophytes have been placed nevertheless reflects current views on their phylogeny.

3.2 Insufficient or unequal response

The questionnaire was very ambitious, imagining an ideal state of knowledge. It was clearly not the intention to do additional research to be able to fill in the questionnaire. Time and resources did not allow it. The answers should reflect the state of readily available knowledge with the specialists. Form 2 was seldomly filled in. The returned copies of form 1 too showed many blanks. For a number of groups no questionnaire was returned, despite further contacts. This was especially the case for some algae with marine planktonic representatives and for many micro-fungi in general, especially the plant pathogens. Apparently no specialists on these groups are available in Belgium. One expert asked to be paid to fill in the forms, a request which could not be honoured by lack of funds.

3.3 Bibliographical research

Additional information was sought if the received or collected answers were insufficient or material of special interest existed to complete the contents of the questionnaires. This was done in various ways: by directly contacting other researchers, in Belgium and abroad, who had not previously received the questionnaire or by searching the Belgian literature or the literature from our neighbouring countries, in some cases also grey literature. The latter category tends to become more and more important, since several main sources of information, often related to short period research contracts, do not reach the public literature. This is a sad evolution in the scientific community. The most striking example was of scientifically highly relevant information found in the newsletter of a firm of laboratory supplies (Valentin et al. 2001), which could not be traced back to a more conventional publication.

For the groups lacking response altogether (marine plankton, micro-fungi, plant pathogens), we tried to estimate or describe the Belgian biodiversity on the basis of the literature mentioned above. Sometimes a specialist did not cover the entire domain of the taxon he or she had been contacted for, or amalgamated information on different taxa on the same questionnaire or used former classification concepts. All this brought about a considerable amount of extra work to try to split up or redistribute information extracted from the questionnaires and again searching for support from the literature. If the task was too huge in this context, we sometimes had to content ourselves with the conclusion that for the time being no summary of knowledge on the respective taxa is available.

For inclusion in the reference list of the different taxonomical paragraphs (Rappé & Rammeloo op.cit.) basic reference texts were selected. If dedicated literature on the identification or status of a taxon in Belgium was not readily available, references of other (western) European literature and/or of a recent general textbook were included.

3.4 Rate of synonymy: what is a valid species?

An often heard definition is: "A species is, what a specialist calls thus". Who are we, non-specialists, to doubt his/her opinion? However, the number of synonyms for a given species can be large. Figures largely depend on the source used. If the conflicting estimates range wide, this has been mentioned in a special column in table 1. A few examples to illustrate:

Conifers. Mabberley (1997) speaks about 598 species of Pinophyta, while Farjon (1998) recognizes 629 species (including 7 nothospecies) of conifers and 176 infraspecific taxa in his checklist, amounting to 805 recognized taxa at species rank and lower. It is hard to believe that the difference accounts for new discoveries in the one year lapse between both publications. Just to illustrate the nature of the problem, Farjon (op.cit.) gives some additional figures on conifers, to let us gain some specific insight. "At these levels, the number of synonyms is 3225, of names with uncertain application (*incertae sedis*) 73, so that the list contains 4103 validly published names of species and infraspecific taxa."

Angiosperms. If one would be inclined to think that the situation is better in the most popular and best studied group, the angiosperms, think again after reading the following. There used to be a consensus about 240,000 (Hawksworth & Kalin-Arroyo 1995) to 250,000 (249,500 by Mabberley 1997) species, an interval of some 10,000. This may seem a lot, and is more than many higher taxa have in total, but we are talking here about a group of considerable size. The difference only accounts for some 4% of the total. Recent attempts have only added to the confusion. Thorne (2000) came up with a figure of 257,400 species. Govaerts (2001) assumes an average synonymy of 58.4 % and thus recalculated the world's total for seed plants to be 422,000. Thorne (2002) again built on his own large expertise in monocotyledons, and added up all the figures from recent monographs and revisions of angiosperms, supplemented by figures from Mabberley (1997) when recent revisions are not available. In this way he counts about 258,650 accepted species of angiosperms and a world total of about 260,000 including the other seed plants. Finally (for the time being) Scotland & Wortley (2003), starting from recent monographs and well known taxa, estimate synonymy much higher, at an average of 78%. Given the total of 1,065,000 published binomial names in Index Kewensis, this would mean that there are only about 223,300 species of seed plants (i.e. gymnosperms included).

Bryophytes. For bryophytes the situation is much the same. There are no good estimates of the globally accepted species total. The number of species of hepatics varies between 1 and 1.2, of hornworts between 1 and 1.5 and for mosses between 1 and 1.67 on a relative scale. Dr Marshall R. Crosby (Missouri Botanical Garden, St Louis), running the World Checklist of Mosses, provided some additional information (in e-mail June 2003). "For mosses, our checklist, using the Index Muscorum as a base and recording all new synonymy, new species etc. since 1964, has about 12,500 species currently, which is a decrease from 12,800 in July 1999, the first time we made the numbers available generally. Our checklist classifies species into better and poorer known ones, and the decrease in the number of species over the past 4 years has been almost entirely in the poorer known class, as the results of additional monographic studies appear. This means that the number of species of mosses may be 7,500-8,500." This is an interesting trend: many more new synonyms have been recognized than new species lately. For the time being I used 'conservative' means for bryophytes in table 1. In general mosses are considered to be more numerous globally than hepatics, but since 1974, the beginning of the period for which Crosby (same communication) is compiling a supplement to the Index Hepaticarum, 1395 new species of hepatics have been described, against only 1286 new species of mosses during the same period. If there are really fewer hepatics than mosses, why are they being described at such a relatively higher rate? Part of the answer may be that mosses gained earlier attention and that hepatics are catching up, but this hypothesis should be tested.

Algae. The worst case are the algae (and protocists in general). Take e.g. the chlorophytes sensu stricto. The figures come from major textbooks. Raven et al. (1999, 2000) mention 17,000

species, while Sitte et al. (2002) are satisfied with 7,000, less than half of the former. Any attempts to find more precise information stranded. The database AlgaeBase (www.algaebase.org) includes 4237 currently-accepted species names of Chlorophyta (comm. M. Guiry, Galway, June 2003). This should be considered as a strict minimum, as the database has mainly focused on marine algae in the beginning and is far from being complete for the freshwater algae at this stage.

Many unicellular algae were described from Belgium in the first half of last century and hardly ever reported again. Their validity is hard to assess. For algae in general, there are about 53,000 names in AlgaeBase of which its managers, Guiry and collaborators, consider 27,000 to be currently accepted names, i.e. a synonymy rate of some 49 %.

Among charophytes s.s. workers there is much controversy too, but this is much more a matter of opinion in this relatively well studied group.

4 Prokaryotic and botanical diversity in Belgium: a summary

Table 1 is a summary scheme of some of the results of the questionnaire, the full results being available in the national monograph (Rappé & Rammeloo op.cit.). The main reason to include it here, apart from being highly informative, is the fact that the original summary table in the recently published national monograph (Peeters et al. 2003, p.90) has unfortunately been represented in an incomplete way, for reasons beyond our comprehension or control.

Compared to the figures mentioned in the national monograph some minor changes have also been made here. These mainly concern systematics, with additional classes presented in the heterokont algae (Kawai et al. 2003) and the streptophycean green algae (Marin & Melkonian 1999), while the 'true' green algae or chlorophytes have been split up between continental (freshwater, terrestrial) and marine algae. This allows to make a better distinction between the disparate levels of knowledge and documentation.

Also included here are any higher taxa that are lacking in Belgium, to show for the record that they have not been forgotten by Rappé & Rammeloo (op.cit.) but simply have no representatives on the Belgian territory. Next to the above mentioned heterokont and streptophycean algae, this meant adding psilotophytes and some gymnosperm taxa. One of the latter may be the proverbial exception to the rule: a representative of gnetophytes, the perennial *Ephedra distachya*, has been observed in the wild, in an appropriate habitat (comm. A. Zwaenepoel). However, its status is unclear: an origin as a garden escape can not entirely be ruled out. An interesting publication (Cavender et al., 1995) came to my attention and some valued opinion could be gained (James Cavender, John Landolt, e-mails October 2003) concerning the cellular slime moulds (acrasids, dictyostelids). Finally some important additional information on the "lichens" group (an artificial gathering of lichenized and lichenicolous fungi) has become available recently (Sérusiaux et al. 2003), allowing the Belgian total to be adjusted.

For reasons of comparison the world's total number of species per taxon and the totals for another, similarly small, country, the Netherlands, have been included in the table. The Netherlands lie in the same biogeographical realm, are in fact our neighbours to the north, and have a similar degree of demographical, economical and scientific development. Figures on botanical taxa of the latter have been extracted or recalculated from 'Biodiversiteit in Nederland' (Nieukerken & van Loon 1995) and 'Natuurcompendium 2003' (CBS 2003, van Duuren et al. 2003).

Three final columns, with the headings 'Knowledge', 'Checklist' and 'Flora', give a state of the art on the knowledge and documentation of the taxa. The rate given in 'Knowledge' is a highly subjective measure, for which the responsibility is entirely the author's. Nevertheless the matter has been given some careful reflection, before attributing a category. The contents of the last two columns highly, but not solely, orientates its outcome: accessibility of information. The

availability of a checklist and/or an identification flora is indeed an important factor in the promotion of the study of a given taxon by a larger group than the occasional specialist. Other factors have to be taken into consideration though. How many workers do actually study the group? How often new additions to the national species list have been reported? What is the ratio between the total number of known species and the total number of expected species? Sometimes only certain 'ecological guilds' or habitats have been well studied, while others attract far less attention, e.g. benthic marine macro-algae (rather wellknown, flora available) versus planktonic micro-algae (poorly studied).

A total of 60 'taxonomical' groupings have been included in table 1, of which 7 probably do not occur at all on the Belgian territory. For 9 of the concerning 53 taxa knowledge is considered to be good (landplants and charophytes s.s.), for 7 moderate to good (marine benthic macro-algae, macrofungi, lichens, Laboulbeniales), for 7 moderate, for 6 from moderate to poor, the remaining 24 are poorly known. For 11 groups we dispose of a complete checklist, for 14 a partial checklist is available. A complete flora is available for the vascular plants, the liverworts and the charophytes s.s., for the marine benthic macro-algae, for the macro-fungi and a limited number of taxa of freshwater algae (see the taxonomical treatments in Rappé & Rammeloo op.cit.).

Due to the many uncertainties and rough estimates in the figures of tabel 1, a precise number of botanical species known in Belgium is hard to give. Between 13,000 and 13,800 species may have been encountered. This total includes cyanophytes, but excludes the other prokaryotic organisms. An even less accurate estimate of the real number occurring, including all expected species, would be in the order of 17,000-19,200 species. In other words, only between 68-81% of the expected flora is known at present, leaving roughly one third to one fifth of Belgium's botanical biodiversity still to be discovered. The Belgian flora thus comprises about 3-4% of the known global species total, estimated here at 386,000 (392,000 if all prokaryotes are included). This is a relatively huge number for a densely populated country with a high degree of development and education.

Table 1. Known and expected number of species of "botanical" taxa in Belgium, compared to the Dutch (NL, grand total extrapolated) and the worldwide species number.

>0, probably/possibly present, in unknown number; xx?, rough estimate; ?, not known; (I), possible garden escape, see text. All columns: Y, yes; N, no; *, not relevant. Rec., recorded number; Low estimate; High estimate; Wo.Be., best estimate of the world species number; Wo.Ra., range of estimates of the world species number; Kn., 'Knowledge' (P, poor; M, moderate; G, good); Ch. 'Checklist' and Flo. 'Flora': F, freshwater; M, marine; B, benthic; P, pro parte.

Taxon	Rec.	Low	High	NL	Wo.Be.	Wo.Ra.	Kn.	Ch.	Flo.
PROKARYOTA (excl. Cyanobacteria)	<6000	<6000	<6000	?	6000	.	P	N	N
"ALGAE"									
Cyanobacteria	300	300	400	?	1700	1400-2000	M	P	FMB
Glaucocystophyta	1	1	2	?	13	.	P	N	N
Chlorarachniophyta	0	0	>0	?	5	.	P	N	N
Euglenophyta	<405	250	400	250	930	.	PM	P	F
Cryptophyta, Cryptomonada	<60	25	50	25	200	.	P	P	F
Haptophyta	22	20	40	c100	300	.	P	N	N
Rhodophyta	53	50	70	78	5500	.	MG	P	FMB
Alveolata									
Dinoflagellata, Dinophyta	200	150	250	c300	4000	.	P	P	F
Stramenopiles, Heterokonta(e)									
"Heterokontophytina"									
chrysophytes' incertae sedis	9	?	9	?	100	.	PM	N	N
"Chrysomerothyceae"	0	0	?	?	7-8	.	P	N	N
Dictyochophyceae	7	7	9	?	25-27	.	P	N	N

Eustigmatophyceae	7	3	7	?	20	.	P	N	N
Chrysophyceae s.s.	185	?	185	(c350)	890	.	PM	N	N
Synurophyceae	<63	30	60	?	151	.	PM	N	N
Bolidophyceae	0	0	>0	?	2	.	P	*	*
Bacillariophyceae	c1600	1600	2600	>1300	12000	.	MP	N	N
Pelagophyceae	1	1	3	?	12	.	P	N	N
Pinguiphyceae	0	0	0	?	5	.	*	*	*
Raphidophyceae	3	5	8	?	28	.	P	P	F
Tribophyceae	105	90	110	120	600	.	MP	N	N
Phaeothamniophyceae	0	0	?	?	26	.	P	*	*
Schizocladiophyceae	0	0	0	0	1	.	*	*	*
Phaeophyceae	29	29	41	73	1700	.	MG	P	M
Chlorophyta	.	.	.	.	12000	7000-17000	.	.	.
freshwater	c860	760	950	1070	.	.	M	N	N
marine	37	40	56	85	.	.	MG	P	MB
Streptophyta									
"Streptophytina"									
Zygnematophyceae	c740	500	750	530	4600	<4770	M	P	P
Klebsormidiophyceae	7	7	8	8	c17	.	M	N	N
Coleochaetophyceae	5	5	5	5	12	1-12	M	N	N
Chlorokybophyceae	0	0	0	0	1	.	*	*	*
Mesostigmatophyceae	1	1	2	1-2	3-4	.	M	N	N
Charophyceae	29	29	30	22	c300	81-450	G	Y	Y
(Embryophyt(in)a)									
"Bryophyt(in)a"									
Anthocerotopsida	5	5	5	4	120	100-150	G	Y	Y
Marchantiopsida / Hepaticopsida	171	171	185	125	5500	5000-6000	G	Y	Y
Bryopsida, Musci	557	557	577	443	9500	7500-12500	G	Y	P
"Pteridophyt(in)a"									
Psilotopsida	0	0	0	0	3	.	*	*	*
Lycopodiopsida	11	11	13	9	1000	.	G	Y	Y
Sphenopsida, Equisetopsida	7	7	8	8	15	.	G	Y	Y
Pteridopsida, Filicopsida	42	40	44	35	11000	.	G	Y	Y
"Spermatophyt(in)a"									
Gymnospermae	.	.	.	.	870	.	.	.	.
Cycadopsida	0	0	0	0	145	.	*	*	*
Ginkgopsida	0	0	0	0	1	.	*	*	*
Coniferopsida	2	2	3	2	630	.	G	Y	Y
Gnetopsida	(1)	0	1	0	80	66-95	*	*	*
Angiospermae	c1350	1250	1430	c1370	230000	222700-258700	G	Y	Y
"FUNGI"						.			
Protocista						.			
Acrasiomycota	?	3	>3	?	12	.	P	N	N
Myxomycota	c300	200	500	c280	900	.	M	P	P
Dictyosteliomycota	2	c10	c15	?	100	.	P	N	N
Alveolata									
Plasmodiophoromycotina	2	2	>2	?	47	.	P	N	N

Stramenopiles, Heterokonta(e)									
"Heterokontomycotina"									
Labyrinthulomycetes	?	?	>0	?	48	.	P	N	N
Oomycetes	100	80	150	?	810	.	P	P	P
Hyphochitriomycetes	?	?	>0	?	23	.	P	N	N
Eumycota									
"Chytridiomycota"	57	60?	150?	?	920	.	P	P	N
"Zygomycota" + Glomeromycota	?	50?	400?	?	1090	.	P	N	N
Ascomycota									
Ascomycota	c2000	1800	2200	c1000	17400	.	MG	P	P
Laboulbeniomyces	100	150	200	?	1900	.	MG	Y	N
Lichenized / lichenicolous fungi	984	985	1000	787	13500	.	MG	Y	N
Basidiomycota									
Basidiomycetes	2910	2570	3350	c2800	20400	.	MG	P	P
Teliomycetes	233-264	300	1000	?	8057	.	P	N	N
Ustomycetes	55-56	100	350	?	1464	.	P	N	N
"Deuteromycetes"	>222	300	2000?	?	16200	.	P	N	N
Total (excl. Prokaryota non-Cyanobacteria)	ca. 13840	ca. 12700	ca. 19600	ca. 12000	ca. 386000				

5 Conclusions

For a developed country we know surprisingly little.

A lot of the figures are the result of educated guess or 'guesstimates' as this kind of approach is often called.

This leads to the conclusion that the knowledge on the biodiversity of Belgium is fragmentary. It is a frustrating thought to see that even in the countries of the world with the best resources the inventory of its natural resources is far from finished.

For a number of reasons the scientific community is not able to offer a general overview of the Belgian biodiversity to fellow scientists, laymen and policy makers.

- A number of groups are (almost) not studied, so no or very few information is available. This is particularly the case for micro-organisms from soil and marine environments, and parasitic and pathogenic agents of non-commercial hosts: bacteria, archaea, marine phytoplankton, zygomycetes, glomeromycetes and other microfungi or pseudofungi (slime moulds, alveolates, heterokonts).
- Linked to the previous: in many cases the knowledge is outdated, going back a century or more.
- A lot of information exists, but is not readily available. We had a hard time trying to find the relevant resources and were not successful in some cases to deliver the information in a satisfactory manner in the given time span.
- A nearly general lack of summaries, checklists, review articles, floras. One gets a very good picture of the Belgian vascular flora by consulting the flora (Lambinon et al. 1998, 2003), which again stimulates interest in vascular plants. Many students of other groups are not so fortunate and have to turn to foreign literature. Apparently researchers, experts and information holders do not feel the need to provide such handy reference tools.
- The job is not finished. The availability of a flora may create the false impression of completeness. A flora for the marine benthic macro-algae exists (Coppejans 1995, 1998), but a

recent survey of groynes and other hard substrates on the Belgian coast revealed many additions to the list (comm. Henry Engledow).

- Constant attention (monitoring) is needed as almost all natural communities are subject to natural (e.g. climate change forced) or human-induced change (e.g. introduction by foreign biota). Especially the ecological consequences of the latter phenomenon being unknown and largely unpredictable, are reason for serious concern.

It clearly remains a vast task for the national institutes involved in the study of our fauna and flora, to keep track of the literature, to draw lists of taxa, to prepare and publish reference works to make biodiversity information available. The need for this is urgent, as our biodiversity continues to erode, despite the efforts of nature conservation. In many cases this work has been supported by keen amateur taxonomists. Both the amateur and professional must be encouraged to continue their efforts. In the case of the latter one cannot help but notice that at many universities the reverse is true.

Strengthening taxonomy as an important basic scientific discipline should be the subject of an urgent and dedicated initiative by the national and regional government, before we lose too much taxa.

Basic knowledge of the earth's and Belgium's biodiversity is the first step to success, but gaining knowledge is not enough. If knowledge exists, it should be made easily available, if it does not exist, some calls for specific research schemes may be necessary.

6 Concluding call

The task of bringing all information on all botanical biodiversity of Belgium together and producing a summary for all taxa was concluded on a 'best professional judgement' basis. The experts themselves answered the questionnaires to the best of their knowledge. However, it is inevitable that the synthesis is incomplete. Please read the accounts in Rappé & Rammeloo (op.cit.) critically and send in your comments, corrections and additions. Thank you.

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Appendix. – Multilingual list of higher prokaryotic and 'botanical' taxa

Abbreviations: p.p., pro parte; s.l., sensu lato; s.s., sensu stricto; **E** English–Engels–anglais–Englisch; **D** Dutch–Nederlands–néerlandais–Niederländisch; **F** French–Frans–français–Französisch; **G** German–Duits–allemand–Deutsch.

- **PROKARYOTA** (excl. Cyanobacteria): **E** prokaryotes, true bacteria and archebacteria; **D** prokaryoten, bacteriën en archaeobacteriën; **F** prokaryotes, bactéries et archéobactéries; **G** Prokaryoten, Bakterien und Archebakterien.
- **"ALGAE"**.
 - Cyanobacteria: **E** blue-green algae, cyanophytes, cyanobacteria; **D** blauwwieren, cyanobacteriën; **F** algues bleues, cyanophycées, cyanobactéries; **G** Blaualgen, Cyanobakterien.
 - Eucarya: **E** eukaryotes; **D** eukaryoten; **F** eucaryotes; **G** Eukaryoten.
 - Glauco(cysto)phyta: **D** glaukwieren; **F** glauco(cysto)phytes.
 - Chlorarachniophyta: **E** chlorarachniophytes; **D** amoebewieren; **F** chlorarachniophytes.
 - Euglenophyta: **E** euglenophytes, euglen(o)ids, euglenoid flagellates; **D** geselwieren, oogwieren; **F** euglenophytes, eugléniens, euglénoïdes; **G** Augentierchen.
 - Cryptophyta, Cryptomonada: **E** cryptophytes, cryptomonads; **D** cryptowieren; **F** cryptophytes, pyrrhophytes p.p.; **G** Schlundgeissler.
 - Haptophyta (syn. Prymnesiophyta): **E** haptophytes, haptomonads, coccolithophorids p.p.; **D** haptowieren; **F** haptophytes; **G** Kalkalgen p.p.
 - Rhodophyta: **E** red algae; **D** roodwieren; **F** algues rouges, rhodophycées; **G** Rotalgen.
 - Alveolata: **E** alveolates; **D** alveolaten; **F** alvéolés; **G** Alveolaten.
 - Dinoflagellata, Dinophyta: **E** dinoflagellates, dinophytes; **D** pantserzweephaarwieren, dinoflagellaten; **F** dinoflagellés, dinoflagellates, pyrrhophytes p.p.; **G** Dinoflagellaten, Panzergeissler.
 - Stramenopiles, Heterokonta(e).
 - "Heterokontophytina", Ochrophyta, Chromophyta p.p.: **D** okerwieren.
 - chrysophytes' incertae sedis: **E** chrysophytes s.l., chrysophyceans, golden(-brown) algae; **D** goudwieren s.l.; **F** chrysophytes s.l.; **G** Goldalgen s.l.
 - "Chrysomerophyceae": **E** chrysophytes s.l., chrysophyceans, golden(-brown) algae; **D** goudwieren s.l.; **F** chrysophytes s.l.; **G** Goldalgen s.l.
 - Dictyochophyceae: **E** silicoflagellates p.p., chrysophytes s.l., chrysophyceans, golden(-brown) algae; **D** silicoflagellaten p.p., goudwieren s.l.; **F** silicoflagellés p.p., chrysophytes s.l.; **G** Goldalgen s.l.
 - Eustigmatophyceae.
 - Chrysophyceae s.s.: **E** chrysophytes s.s., chrysophyceans p.p., (true) golden(-brown) algae; **D** goudwieren s.s., echte goudwieren; **F** chrysophytes s.s., chrysophycées.; **G** Goldalgen s.l.
 - Synurophyceae: **E** chrysophytes s.l., chrysophyceans, golden(-brown) algae; **D** goudwieren s.l.; **F** chrysophytes s.l.; **G** Goldalgen s.l.

- Bolidophyceae.
 Bacillariophyceae, Diatomeae: **E** diatoms; **D** kiezelwieren, diatomeeën; **F** diatomées; **G** Diatomeen, Kieselalgen.
 Pelagophyceae: **E** chrysophytes s.l., chrysophyceans, golden(-brown) algae; **F** chrysophytes s.l.; **G** Goldalgen s.l.
 Pinguiphyceae.
 Raphidophyceae, Chloromonadophyceae, Chloromonadida: **F** raphidophycées.
 Tribophyceae, Xanthophyceae: **E** yellow green algae, xanthophytes; **D** geelgroene wieren; **F** xanthophycées; **G** Gelbgrünalgen.
 Phaeothamniophyceae: **E** chrysophytes s.l., chrysophyceans, golden(-brown) algae; **D** goudwieren s.l.; **F** chrysophytes s.l.; **G** Goldalgen s.l.
 Schizocladiophyceae.
 Phaeophyceae: **E** brown algae; **D** bruinwieren; **F** algues brunes, phaeophycées; **G** Braunalgen.
Chlorophyta: **E** green algae; **D** groenwieren s.s., groenwieren 1, echte groenwieren; **F** algues vertes; **G** Grünalgen I.
Streptophyta.
"Streptophytina": **E** streptophycean algae; **D** groenwieren s.l. p.p., groenwieren 2, streptowieren; **F** algues vertes; **G** Grünalgen II.
 Zygnematophyceae: **E** zygnemataleans, zygnematophyceans; **D** voegwieren, jukwieren s.l.; **F** zygnematophycées, conjuguées; **G** Konjugaten, Jochalgen.
 Zygnematales: **D** jukwieren s.s.; **G** Jochalgen.
 Desmidiáles: **E** desmids; **D** sierwieren; **F** desmidiées; **G** Zieralgen.
 Klebsormidiophyceae: **E** charophytes s.l.
 Coleochaetophyceae: **E** charophytes s.l., coleochaetaleans s.s.
 Chlorokybophyceae: **E** charophytes s.l.
 Mesostigmatophyceae: **E** charophytes s.l.
 Charophyceae: **E** charophytes s.s., charaleans; **D** kranwieren; **F** charophytes; **G** Armleuchteralgen.
- **(EMBRYOPHYT(IN)A)**: **E** embryophytes, land plants; **D** landplanten, embryofieten; **F** embryophytes; **G** Embryophyten, echte Landpflanzen.
"Bryophyt(in)a": **E** bryophytes, land plants; **D** mosplanten; **F** bryophytes; **G** Moose, Moospflanzen.
 (Anthocerophytina) Anthocerotopsida: **E** hornworts; **D** hauwmossen; **F** anthocérotes; **G** Hornmoose.
 (Marchantiophytina, Hepatophytina) Marchantiopsida, Hepaticopsida: **E** liverworts; **D** levermossen; **F** hépatiques; **G** Lebermoose.
 (Bryophytina) Bryopsida, Musci: **E** mosses; **D** bladmosse; **F** mousses; **G** Laubmoose.
 (Tracheophyt(in)a): **E** vascular plants; **D** vaatplanten; **F** plantes vasculaires; **G** Gefäßpflanzen, Tracheophyten.
"Pteridophyt(in)a": **E** seedless vascular plants; **D** varenplanten; **F** ptéridophytes; **G** Farnpflanzen.
 (Psilotophyta) Psilotopsida: **D** kwastvaren; **G** Gabelblattgewächse.
 (Lycophyta) Lycopodiopsida : **E** lycophytes; **D** wolfsklauwachtigen, lycofieten; **F** lycophytes; **G** Bärlappgewächse.
 Lycopodiaceae: **E** clubmosses; **D** wolfsklauwen; **F** lycopodes; **G** Bärlappe.
 Selaginellaceae: **E** lesser clubmoss; **D** mosvaren; **F** sélaginelles; **G** Moosfarne.
 Isoetaceae: **E** quillworts; **D** biesvaren; **F** isoètes; **G** Brachsenkraut.

(Sphenophyta) Sphenopsida, Equisetopsida: **E** horsetails; **D** paardestaarten; **F** prêles;
G Schachtelhalmgewächse, Schachtelhalme.

(Pterophyta) Pteridopsida, Filicopsida: **E** ferns; **D** varens; **F** fougères; **G** Farne.

"Spermatophyt(in)a": **E** seed plants; **D** zaadplanten; **F** plantes à graines, spermatophytes;
G Samenpflanzen, Spermatophyten.

"Gymnospermae": **D** naaktzadige planten; **F** gymnospermes; **G** Nacktsamer,
 Gymnospermen.

(Cycadophyta) Cycadopsida: **D** cycaspalmen; **F** cycadopsides; **G** fiederblättrige
 Nacktsamer, Palmfarne, Samenfarne.

(Ginkgophyta) Ginkgopsida: **E** ginkgo; **D** ginkgo, japanse notelaar; **F** ginkgo;
G Ginkgobäume.

(Coniferophyta) Coniferopsida: **E** conifers; **D** naaldbomen, coniferen; **F** conifères;
G Nadelbäume, Nadelhölzer, gabelnervige Nacktsamer.

(Gnetophyta) Gnetopsida: **E** gnetophytes; **D** gnetofieten; **F** préangiospermes,
 gnétophytes; **G** Chlamydospermen, Gnetophyten.

(Magnoliophyta) Angiospermae, Magnoliopsida: **E** flowering plants; **D** bloemplanten,
 bedektzadige planten, angiospermen; **F** angiospermes, plantes à fleurs;
G Angiospermen, Blütenpflanzen, Bedecktsamer.

"Magnoliidae": **E** paleoherbs, noneudicots; **D** oerkruiden **F** paléoherbes.

Liliidae: **E** monocots; **D** monocotylen, eenzaadlobbigen; **F** monocotylédons
G Monokotyledonen, Einkeimblättler.

Rosidae: **E** eudicots; **D** eudicotylen, echte dicotylen, echte tweezaadlobbigen;
F eudicotylédons **G** Eudikotyledonen, echte Zweikeimblättler.

• "FUNGI".

• Protoctista.

Acrasiomycota: **E** lobopodian cellular slime moulds, acrasid cellular slime moulds;
D (cellulaire) slijmzwammen; **F** myxomycètes cellulaires; **G** zellige
 Schleimpilze.

Myxomycota: **E** true slime moulds; **D** (plasmodiale) slijmzwammen; **F** myxomycètes
 plasmodiaux; **G** Myxomyceten, (echte) Schleimpilze.

Dictyosteliomycota, Dictyostylida, Dictyostelida: **E** filopodian cellular slime moulds,
 dictyostelid cellular slime moulds; **D** (cellulaire) slijmzwammen;
F myxomycètes cellulaires; **G** zellige Schleimpilze.

Alveolata.

Plasmodiophoromycotina: **E** endoparasitic slime moulds; **D** plasmodioforen, parasitaire
 slijmzwammen; **F** myxomycètes parasites; **G** parasitische Schleimpilze.

Stramenopiles, Heterokonta(e).

"Heterokontomycotina", "Pseudofungi".

Labyrinthulomycetes-Thraustochytrids: **E** net slime moulds, slimenets; **F** **D**: Algenpilze.

Oomycetes: **E** oomycetes, downey mildews, water moulds; **D** waterschimmels p.p.;
F oomycètes, champignons aquatiques p.p.; **G** Cellulosepilze, Algenpilze.

Hyphochitriomycetes.

• **Eumycota**: **E** true fungi; **D** (echte) zwammen; **F** champignons; **G** Chitinpilze, echte Pilze.

"Chytridiomycota": **E** chytrids; **F** chytrides; **G** Flagellatenpilze.

"Zygomycota" and Glomeromycota: **E** zygomycetes; **D** jukzwammen, wierzwammen;
F zygomycètes; **G** Jochpilze.

Ascomycota: **E** ascomycetes; **D** zakjeszwammen; **F** ascomycètes; **G** Schlauchpilze.
 Ascomycota (excl. Laboulbeniales and Lichenes).

- Laboulbeniomyces: **E** laboulbeniales; **D** laboulbenialen; **F** laboulbéniales;
G Laboulbenialen.
- Lichenes: **E** lichens, lichenized fungi; **D** korstmossen; **F** lichens; **G** Lichenes, Flechten.
- Basidiomycota**: **E** basidiomycetes; **D** steeltjeszwammen; **F** basidiomycètes; **G** Ständerpilze.
- Basidiomycetes (incl. Hymeno- en Gasteromycetes).
- Teliomycetes (incl. Uredinales): **E** rusts; **D** roestzwammen; **F** rouilles, urédinées;
G Rostpilze.
- Ustomycetes (incl. Ustilaginales): **E** smuts; **D** brandzwammen; **F** charbons, ustilaginées ;
G Brandpilze.
- "Deuteromycetes", Fungi Imperfecti: **E** deuteromycetes, mitosporic fungi; **D** deuteromyceten;
F deutéromycètes, champignons imparfaits; **G** Deuteromyceten.



Abstracts of other contributions to Belgian floristics

(Note : Some abstracts of the proceedings are hard to classify under only one heading.
Especially readers with a floristic interest should also check under the next chapter.)

Biodiversité des formations herbacées du réseau autoroutier wallon

Martin Tanghe, Monique Van Craenenbroeck & Jean-Claude Moniquet

Université Libre de Bruxelles, Department of Botany, Laboratoire de Botanique systématique
et de Phytosociologie - Ecologie Végétale et Aménagement du Territoire,
Avenue F.D. Roosevelt, 50, Campus du Solbosch, B-1050 Bruxelles, Belgium
mtanghe@ulb.ac.be

Dès les années 1970, les scientifiques préoccupés de biodiversité constatent que, dans une Europe livrée à une politique agricole productiviste, les dépendances vertes du réseau autoroutier acquièrent de l'intérêt comme refuges de la vie sauvage et comme corridors écologiques dans l'optique du réseau écologique.

La biodiversité maximale est liée à la végétation herbacée, mais le maintien de celle-ci pose le problème des frais d'entretien. Informé du rôle écologique des autoroutes, le Ministère wallon de l'Équipement et des Transports a chargé le Laboratoire de Botanique systématique et de Phytosociologie, par le biais du GIREA (Groupe Interuniversitaire de Recherche en Ecologie Appliquée), d'étudier les modalités d'entretien des espaces verts herbacés des autoroutes de la Belgique méridionale qui soient satisfaisantes tant du point de vue écologique qu'économique. Depuis 1996, quatre conventions de recherche successives portant sur les autoroutes E411, E25, E42 et E19 ont permis un échantillonnage extensif de la végétation herbacée, soit 205 relevés phytosociologiques assortis d'analyses pédologiques et de mesures de la phytomasse.

Ceux-ci ont débouché sur l'identification d'une vingtaine de types phytoécologiques d'herbages définis par leur composition floristique, leurs conditions pédologiques et leur niveau de production. A chacun d'eux sont assorties des modalités d'entretien s'exprimant en termes de période et de fréquence de fauche.

Etendues à l'ensemble de l'autoroute découpée en sections écologiquement homogènes, les modalités de gestion ont été traduites cartographiquement par une symbolique appropriée, à l'usage des gestionnaires et entreprises de fauchage. A l'instar des réserves naturelles dont ils constituent de précieux compléments, les sites les plus intéressants biologiquement bénéficient d'une gestion particulière visant à conserver, voire accroître, leur biodiversité et font l'objet de fiches descriptives individuelles.

Floristic diversity in managed forests of Ardenne

Gaëtan du Bus de Warnaffe

Unité des Eaux et Forêts, Université Catholique de Louvain,
Place Croix du Sud 2, bte 9, B-1348 Louvain-la-Neuve, Belgium; dubus@efor.ucl.ac.be

Forest management aiming mainly at wood production may participate to biodiversity erosion at landscape level. Our aim was to compare the effect of six silvicultural systems widely used in

Europe on the diversity, composition and structure of vascular plants, nesting birds and carabid beetles species assemblages. At Meise, we present some results concerning vascular plant communities. 23 forests and 134 plots were studied by means of a well controlled sampling scheme based on age, structure and composition of forest stands, thereby providing a two-scale approach (local and landscape). For the statistical analysis, we used non-parametric KW tests, ordinations, clustering and IndVal procedure (Dufrêne & Legendre, 1997). 158 vascular plant species were recognised but most of them were common species for Belgium. First results are : (1) species richness does not significantly differ between silvicultural systems, but is clearly affected by stand age and by structure and composition at local scale ; (2) even small cuttings can produce the “open habitat” effect characterised by high species richness; (3) species profiles differs strongly between habitat types ; (4) young stages (0-10 years) and oak stands have particular communities ; (5) number of significant species-habitat relations can be found. Management implications are discussed in reports and papers.

Geographical distribution and changes in the flora of Flanders
Wouter Van Landuyt¹ & Leo Vanhecke²

¹ Institute of Nature Conservation, Kliniekstraat 25, B-1070 Brussel, Belgium
² National Botanic Garden of Belgium, Domein van Bouchout, B-1870 Meise, Belgium

Distribution data are the most valuable data for measuring biodiversity and biodiversity change in Flanders. Since 1940 the distribution of plant species in Belgium has been mapped using a systematic method based on a grid of 1 km² and 16 km². The first results of this mapping project were published in 1972 (Atlas van de Belgische en Luxemburgse flora, Van Rompaey & Delvosalle 1972). In this publication the 16 km² grid unit was used. In 1972 a second mapping project was started using the same method. The comparison of both mapping projects was used to monitor the change in distribution af plant species in Flanders.

Method. Trends in the flora were calculated by combining species in ecotope types (Runhaar et al. 1987, Witte 1998). The distribution of species groups is used for measuring the abundance of the different ecotypes (number of grid units in which the ecotope type is recorded). The completeness of the species-group is used to measure the quality of the ecotope in the grid unit. The completeness of the species-group is determined by the number of species in which highly indicative species get a higher value. Maps with distribution combined with completeness show the important areas for each ecotope.

More detailed information on trend of the ecotope types is derived from a selection of grid units sufficiently investigated in both periods.

Combining trend (% change) and abundance defines the treaths on certain ecotopes into internationally accepted categories (table 1).

Table 1. Description of the treaths on ecotopes based on internationally accepted categories.					
	Extremely rare	Very rare	Rare	Rather rare	Rather common
Strong decline (-40 tot -100%)	critically endangered	endangered	endangered	vulnerable	near threatened
Decline (-20 tot -40 %)	endangered	endangered	endangered	vulnerable	near threatened
Moderate decline (-10 tot -20 %)	vulnerable	vulnerable	vulnerable	vulnerable	near threatened

Results. Trend and abundance of each ecotope type are shown in figure 1.
Two ecotope types are critically endangered: herbaceous vegetations on alkaline, wet and nutrient poor soils; herbaceous vegetations on salty, wet soils.

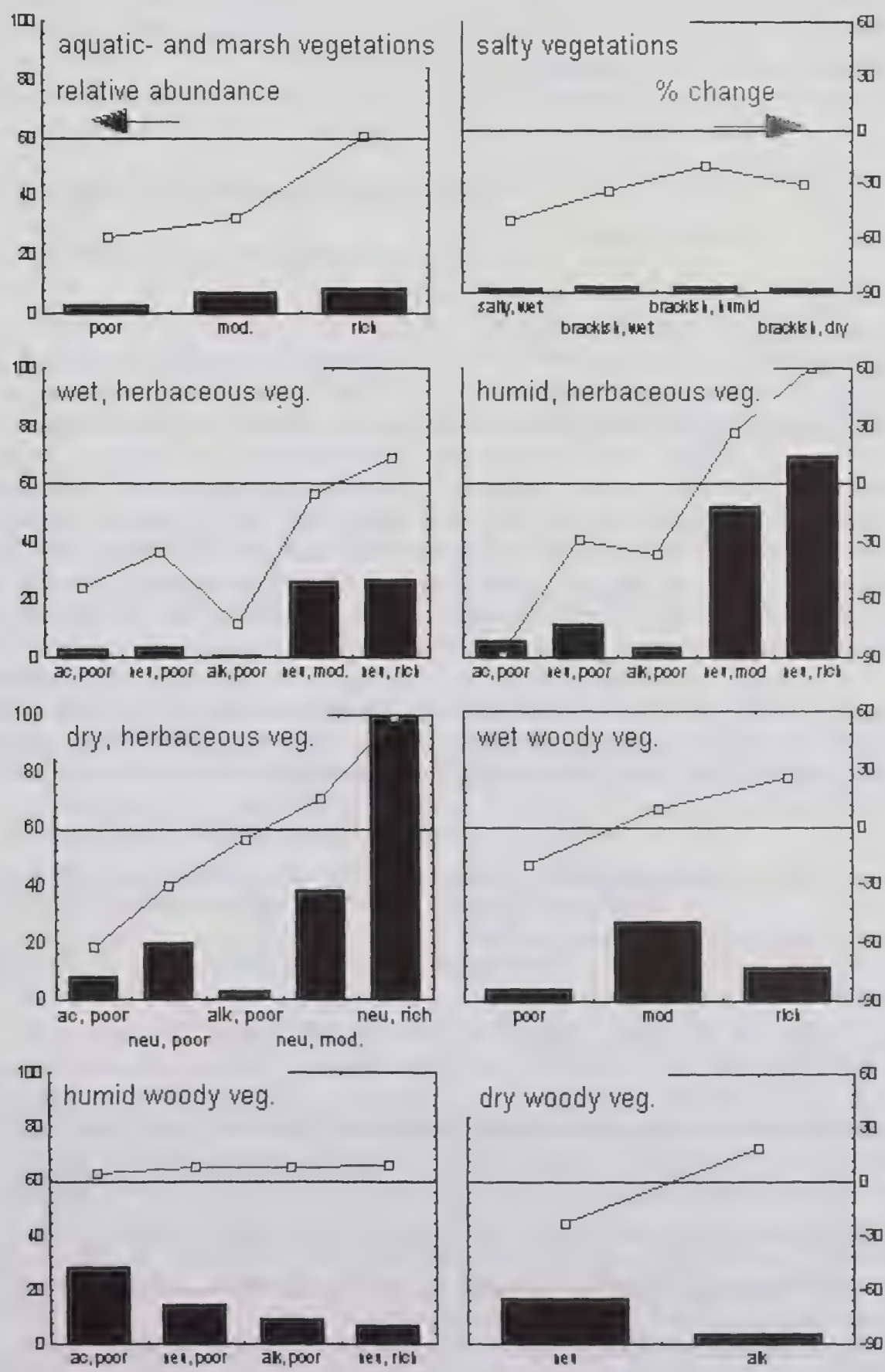


Figure 1. Trend and abundance of a selection of ecotopes(acid-neutral-alkaline/rich-poor) in Flanders.

Ten ecotope types are endangered: aquatic and marshy vegetations of nutrient poor sites; aquatic and marshy vegetations of moderately nutrient rich sites; herbaceous vegetations on brackish, wet soils; herbaceous vegetations on brackish, humid soils; herbaceous vegetations on brackish, dry soils; herbaceous vegetations on acid, nutrient poor, wet soils; herbaceous vegetations on neutral, nutrient poor, wet soils; herbaceous vegetations on neutral, nutrient poor, humid soils; herbaceous vegetations on alkaline, nutrient poor, humid soils; woody vegetations on moderately acid, nutrient poor, wet soils.

Other ecotope types are vulnerable (3), declining (3), rare (3) or actually not threatened (7).

Kranswieren (Characeae) in de Belgische kustduinen

Luc Denys & Jo Packet

Instituut voor Natuurbehoud, Kliniekstraat 25, B-1070 Brussel, Belgium

luc.denys@instnat.be

Kranswieren (Charophyceae) zijn belangrijke doelsoorten voor duinwateren. Mede op basis van een recente inventarisatie wordt een overzicht gegeven van het voormalige en actuele voorkomen van deze groep in de Belgische kustduinen. Van de 11 ooit in het gebied aanwezige taxa zijn er 6 nog na 1997 waargenomen. Deze vertegenwoordigen 25 % van de Vlaamse kranswierenflora. *Chara contraria*, *C. major* en *C. vulgaris* var. *longibracteata* zijn heden de meest frequent optredende taxa. *Chara aspera*, *C. baltica* en *Nitella translucens* zijn reeds geruime tijd verdwenen en hun herverschijning is zeer onwaarschijnlijk. Het duingebied is van bijzonder belang voor het voortbestaan van *Chara major* in Vlaanderen. De Westhoek (De Panne) en de nabijgelegen duincomplexen vormen voor kranswieren het voornaamste deelgebied. Het optreden van kranswieren in de duinen is sterk aan pioniersomstandigheden gekoppeld, zodat een kranswiergericht beheer mede hierop dient te steunen. Tevens dient elke vorm van eutrofiëring vermeden te worden. Meer algemeen is het vrijwaren en zo mogelijk herstellen van de karakteristieke hydrologie en dynamiek van het duinsysteem ook hier essentieel. Het in de toekomst meer regelmatig opvolgen van kranswieren in het duingebied verdient aanbeveling. Dit is zeker niet louter aan 'professionele' botanisten voorbehouden.

Diversity characteristics of sediment diatom assemblages from lentic freshwaters (Flanders, Belgium): geographic differences and historical changes

Luc Denys

Instituut voor Natuurbehoud, Kliniekstraat 25, B-1070 Brussel, Belgium

luc.denys@instnat.be

In general, conservationists are inclined to higher estimate limnic ecosystems with increasing taxonomic diversity and complexity of community structure. If historical conditions before the 20th century agro-industrial revolution are considered to represent an appropriate picture for sustainable freshwater biodiversity in a heavily developed region such as Flanders, this reference needs to be placed in a pragmatic perspective. Diatoms are one group of representative cryptobiota where the reference can be extended from a mere local scale (site) to a broader geographical view, as historical data on species assemblages can be obtained from archives with a wider distribution, e.g. herbarium specimens of aquatic macrophytes. Using such evidence, it may also be possible to examine whether the regional differentiation of freshwaters has been affected anthropogenically in more recent times; e.g. are biogeographic patterns fading?

So far, general diversity characteristics of lentic freshwater diatom assemblages in Flanders have received little attention. A previous comparison of historical and recent survey data indicates that the abundance, and to a lesser extent incidence, of disturbance-sensitive specialists decreased in the Campine region due to human impacts (Denys, 2000), but the overall effects on inventory

and differentiation diversity remain obscure. Trends are now examined from a more extensive study, comprising 213 recent and 118 pre-1945 samples of sediment assemblages, and using various metrics of α diversity (estimators of taxonomic richness, diversity indices), ecological distance measures (compositional turnover, average distances), multivariate methods (MRPP, DCA) and analyses of specificity, fidelity and indicator species. Among others, the results suggest an increase of α diversity, but – except in the Campine region, where the reverse occurred – a decrease in between-site variation. Whereas diatom assemblages from other regions appear to have become somewhat more similar to each other by an expansion of 'generalists' in favour of 'specialists', the Campine now stands out even more distinctly than before.

Reference. – Denys L. (2000) Historical distribution of 'Red List diatoms' (Bacillariophyceae) in Flanders (Belgium). *Syst. Geogr. Pl.* **70**: 409-420.

The role of fungi in the decomposition of *Phragmites australis* in the Schelde-estuary: preliminary results

Gunther Van Ryckegem & Annemieke Verbeken

Universiteit Gent, Department of Biology, Laboratory of Botany - section Mycology,
K.L.Ledeganckstraat 35, B-9000 Gent, Belgium
Gunther.vanryckegem@UGent.be

Reed-vegetations are among the most productive ecosystems on earth. A huge amount of biomass is produced every year, and has to be decomposed again. Fungi are important in this process and the biodiversity of phragmiticolous fungi has been shown to be very high. To search for the role of fungi in this decomposition process, one needs qualitative as well as quantitative information. This project aims at 1) defining the biodiversity linked at the ecological preference of fungi on reed, 2) studying the succession of species taking part in the decomposition of reed and 3) monitoring the decomposition progress by measuring the fungal biomass. The results of the first part of this PhD-research are presented here. 186 taxa are hitherto recorded from reed in the Schelde-estuary, three of them have been described as new species, a few others are waiting to be described. The fungal succession has been followed in situ in two PQ's. Coelomycetes are the dominant group in the first phase of the succession. The species composition varies depending on the plant parts and the height of the culms. Some provisional conclusions are discussed.

Au-delà de la checklist, qu'advient-il des lichens en Belgique et au Grand-Duché de Luxembourg?

Paul Diederich & Emmanuël Sérusiaux

University of Liège, Department of Botany, Laboratory of Systematics and Phytogeography
boulevard du Rectorat, 27, B-4000 Liège, Belgium
Paul.Diederich@ci.educ.lu

Une checklist annotée des lichens et des champignons lichénicoles a été publiée en 2000 pour la Belgique, le Grand-Duché de Luxembourg et l'extrême Nord de la France: 1151 taxons sont acceptés, dont 930 lichens, 201 champignons lichénicoles et 20 espèces apparentées mais n'appartenant pas à l'un des deux groupes biologiques cités.

Pour chaque espèce, les informations suivantes sont présentées: nom, avec le statut biologique du taxon; synonymes courants ou utilisés dans la littérature belge ou luxembourgeoise; [connexions entre téléomorphes et anamorphes]; écologie dans le territoire étudié; répartition par districts phytogéographiques; commentaires éventuels; littérature pour le territoire étudié.

Les auteurs estiment qu'au moins une cinquantaine de taxons pourront être ajoutés à cette liste dans les prochaines années, notamment par l'identification du matériel resté non déterminé jusqu'ici et par une exploration soutenue des sites les plus intéressants du territoire concerné. Une

extension de la zone d'étude vers le Boulonnais se concrétisera prochainement par la publication d'une première liste des taxons présents dans cette zone.

L'augmentation récente et très rapide du nombre d'espèces de lichens et de champignons lichénicoles connues dans le territoire étudié est dû à un effort tout particulier de recherches, et ne doit pas faire oublier que de très nombreuses espèces y sont dans un état de conservation très précaire. Les facteurs affectant principalement la survie de ces organismes sont les suivants:

- la pollution atmosphérique, et notamment la pollution à l'ozone
- les aménagements forestiers, en particulier l'abaissement des nappes phréatiques, l'absence de (très) vieux arbres et de troncs morts (sur pied ou couchés), et l'absence de stabilité de l'écosystème forestier dans le temps
- la disparition des milieux semi-naturels, et tout particulièrement des stades pionniers dans les landes et les pelouses calcaires
- la disparition des ormes
- la pratique de l'escalade sur les rochers naturels

L'ouvrage peut être commandé à l'adresse www.mnhn.lu/recherche/lichens/order.htm (25 Euros).

Epiphytic-lichenological survey of the Brussels Capital Region

Bert Vanholen

National Botanic Garden of Belgium, Domein van Bouchout, B-1860 Meise, Belgium

[At present: Aminal afd. Natuur, Taxandriagebouw, Gouverneur Roppesingel 25, B-3500 Hasselt, Belgium]

bert.vanholen@instnat.be

Since 1970, a constant improvement of the Brussels air quality has been observed. In order to study possible changes in the epiphytic lichen flora, a survey of the Brussels Capital Region was conducted in the spring of 2000. The study is limited to the macrolichens.

Each of the 164 1 km² IFBL coordinates was subdivided in 64 parts. 470 of these subcoordinates were visited. Where access was possible and phorofytes were present, a changing number of phorophytes was investigated. Exposition, location on the tree, fertility and vitality of the species were noted. For some species, the diameter of the thalli was measured. Ecological data of the site were collected.

Approximately 1.200 trees were investigated. The survey yielded 4.347 observations.

The lichen flora of Brussels seems to recover from past pollution; Brussels can no longer be considered as a lichen desert. 32 species were discovered during the survey of 2000. Some of these species, e.g. representatives of the genus *Usnea*, are very sensitive to air pollution.

The distribution of the number of species per IFBL coordinate is shown. Two IFBL coordinates contain 19 species. The average number of species is 9,44. The average diameter of *Parmelia sulcata* Taylor per IFBL co-ordinate is shown.

[Note: the survey has been published as: **Vanholen B.** (2003) Epifytische macrolichenen van het Brussels Hoofdstedelijk Gewest Anno 2000. *Scripta Botanica Belgica* 26: 1-60.]

Underground biodiversity. Check-list commentée des champignons hypogés (Ascomycotina, Basidiomycotina, Zygomycotina & Deuteromycotina) de Belgique et du Grand-Duché de Luxembourg

Daniel Thoen¹ & Ben Schultheis²

¹ Fondation Universitaire Luxembourgeoise, avenue de Longwy, 185, B-6700 Arlon, Belgique ; E-Mail : thoen@ful.ac.be

² Rue du Village, 20, L-3311 Abweiler, Luxembourg

L'analyse de la diversité des champignons hypogés en Belgique et au Grand-Duché de Luxembourg montre que depuis la parution du premier catalogue concernant ces organismes dans

la dition (Thoen, 1988), le nombre d'espèces reconnues est passé de 47 à 64, soit un accroissement d'environ 27%. Cette augmentation est due à une prospection plus intense et plus systématique de sites favorables, principalement en Lorraine belge et en Lorraine luxembourgeoise (Gutland). Pour le Grand-Duché de Luxembourg, le nombre d'espèces répertoriées est passé de 14 à 44 (!), avec 10 espèces non encore observées en Belgique. Les terrains calcaires sont plus riches que les terrains acides, mais un certain nombre d'espèces sont préférentielles de ces derniers. La plupart des hypogés sont des espèces symbiotiques qui forment des ectomycorhizes avec certains arbres et arbustes. On observe tout une gamme d'inféodation vis-à-vis du spectre d'arbres-hôtes (de paucispécifique à plurispécifique). La dépendance de la maturation des sporocarpes vis-à-vis des conditions climatiques (pluviosité et température) est certainement importante. Cependant, le caractère plus tamponné du microclimat édaphique fait que certaines espèces d'hypogés peuvent mûrir et se récolter quasi toute l'année (*Elaphomyces* spp. et *Hymenogaster* spp., p.ex.). Les plantations d'arbres exotiques peuvent héberger des espèces autochtones, ainsi que des espèces allochtones. Le cas le mieux connu étant celui du Sapin de douglas sous lequel on peut récolter des *Rhizopogons* d'origine nord américaine, comme *Rhizopogon villosulus*. Parmi les écotopes favorables aux hypogés, en plus des bois et forêts, soulignons l'intérêt des éléments du maillage écologique tels que les alignements d'arbres, les arbres isolés, les lisières, les haies (jeunes ou vieilles !), les plantations sur talus et bermes d'autoroutes, les parcs, les jardins plus ou moins arborés. Les freins à une meilleure connaissance des hypogés restent le faible nombre de mycologues qui s'y intéressent ainsi que le choix, plus ou moins aléatoire et imprécis, de l'endroit où les rechercher.



Species richness of mosses, fungi and vascular plants on coarse woody debris of beech in the Flemish forest reserve 'Kersselaerspleyn' (Zoniënwood)

Kris Vandekerckhove^a, Klaas van Dort^b, Hans Baeté^a & Ruben Walley^a

^a Institute for Forestry and Game Management, Gaverstraat 4, B-9500 Geraardsbergen, Belgium

^b Alterra, Green World Research, P.O. Box 47, N-6700 AA Wageningen, the Netherlands

Author for correspondence [kris.vandekerckhove@lin.vlaanderen.be]

Abstract. – *Strict Forest Reserves can play an important role in the conservation and development of botanical richness in forests. Especially the high amount of dead wood, composed of all dimensional classes and decomposition stages, performs as a suitable substrate for often specialized species of vascular plants, fungi and mosses. An international research programme was conceived to analyse this botanical richness, more specifically on dead wood of beech. In this paper some general preliminary results for the research site in the Zoniën-forest are presented.*

Samenvatting. – *Soortenrijkdom van mossen, zwammen en vaatplanten op ruw houtafval van beuk in het Vlaams bosreservaat 'Kersselaerspleyn' (Zoniënwood). Strikte bosreservaten kunnen een belangrijke rol spelen in het behoud en de ontwikkeling van de botanische rijkdom van bossen. Vooral de grote hoeveelheid dood hout, in allerlei afmetingen en toestanden van ontbinding, vormen een geschikt substraat voor dikwijls gespecialiseerde soorten vaatplanten, zwammen en mossen. Een internationaal onderzoeksprogramma werd opgesteld om deze botanische rijkdom te bestuderen, meer bepaald deze van dood beukenhout. In deze bijdrage worden een aantal voorlopige resultaten van het onderzoeksterrein in het Zoniënwood voorgesteld. Vertaald door de redactie.*

Résumé. - *Richesse en espèces des mousses, champignons et plantes vasculaires sur débris grossiers de hêtre dans la réserve forestière "Kersselaerspleyn" (Forêt de Soignes). Les Réserves Forestières intégrales peuvent jouer un rôle important dans la conservation et le développement de la richesse botanique des forêts. En particulier, la quantité importante de bois mort, composée de toutes les classes dimensionnelles dans des états de décomposition divers, fournit un substrat adapté pour des espèces souvent spécialisées de plantes vasculaires, de mousses et de champignons. Un programme international de recherche a été conçu pour analyser cette richesse botanique, plus spécialement sur bois mort de hêtre. Dans cet article sont présentés quelques résultats préliminaires obtenus dans ce site de recherches de la Forêt de Soignes. Traduit par la rédaction.*

Keywords: *dead wood, strict reserve, botanical diversity, vascular plants, mosses, fungi*

Abbreviations: *DBH, Diameter at Breast Height (tree diameter at 130 cm height)*

1 Introduction

Strict Forest Reserves are forest areas that are deliberately left for free development (Parviainen & al. 2000). They are designated and conceived in order to allow natural disturbances and processes to occur. For a better close-to-nature management of forests, the study of the mechanisms of natural dynamics is essential and of the utmost importance (Leibundgut 1966; Mayer 1976; Zukrigl 1990; Broekmeyer 1995). Comparisons of strict reserves to managed areas moreover allow a better understanding and evaluation of the impact of forest management on the ecosystem (Bücking & al. 1998).

Apart from their scientific importance, strict forest reserves also play an important role for conservation and development of biological diversity in forests (Hermy 1988; Albrecht 1990). When comparing strict forest reserves to other forest sites managed in a multifunctional, close-to-nature approach, the main structural difference is probably the presence of very large, old trees, and especially the high amount of dead wood, composed of all dimensional classes and decomposition stages (Christensen & Emborg 1996; Bücking & al. 1998). This dead wood component and correlated aspects like uprootings, represent a suitable substrate for often highly specialised organisms, not only for fauna (saproxylic organisms) and the obvious saproxylic fungi, but also for vascular plants and mosses.

2 Aims and Methods

2.1 Aims

In order to achieve a better understanding of the richness in vascular plants, mosses and fungi on dead wood in forests, an international research project was conceived to analyse the botanic biodiversity on Coarse Woody Debris (CWD) of beech (*Fagus sylvatica*) in strict reserves in 4 European countries (Slovenia, Hungary, the Netherlands and Denmark), within the framework of the NatMan-project (EU 5th Framework -NAT-MAN project : 'study of the dynamics of natural beech forests; knowledge to be used as a reference for the development of a nature-based management strategy for the European beech forests.'). Aims of the project are to identify the importance of beech-CWD as habitat for plant and fungal biodiversity, and to produce an ecological succession model for plant and fungal community development on beech-CWD.

An additional location in Belgium was provided and studied by The Institute of Forestry and Game Management, in collaboration with Alterra (NL) according to the same standardised methodology, thus allowing further comparison with the other four countries in the future. This paper presents some of the preliminary results for the Belgian study site.

2.2 Study site

Since 1995 an official network of forest reserves has been developed for Flanders (Northern Belgium) (Vandekerkhove 1998; Vandekerkhove & Van Den Meersschaut 1999). Up to now a total area of about 1700 ha, divided over 41 sites is officially declared forest reserve, including both strict reserves (no intervention) and managed reserves, so-called 'directed reserves' (Vandekerkhove 2001). One of the most important sites included in the current network is the forest reserve 'Kersselaerspleyn', a 98 ha forest reserve in the center of the beech forest of Zoniën (4300 ha), south of Brussels. The actual forest stand developed on a thick, severely lessivated, acid loamy topsoil of Quarternary niveo-eolian origin, covering an impermeable clay layer on top of a calcareous sandy layer both of Tertiary marine origin, resulting in a Pseudogley soil. Soils are classified as Luvisols and Podsoluvisols (FAO 1988). The dominating forest type is *Milio-Fagetum* (Noirfalise 1984).

The forest reserve consists of two distinct areas. The main area is a beech-dominated mixed stand of about 150 years old. Other tree species intermixed include ash (*Fraxinus excelsior*), oak

(*Quercus robur* and *Quercus petraea*) and Scots pine (*Pinus sylvestris*). It has been left unmanaged only since 1995 and includes low amounts of dead wood, as windblown and other dead trees were removed within the regular management of the stand. An area of about 15 ha however is much older, and consists mainly of a homogeneous beech stand, planted ca 1775 (Van Den Berge & al. 1990a, 1990b). It has been left unmanaged since 1983, when a first storm blew down a number of trees (about 30 m³/ha). Many more trees were uprooted during the storms of 1990, thus producing a total volume of dead wood amounting to about 110 m³/ha , while the standing volume declined from 712 m³/ha to 629 m³/ha (Van Den Berge & al. 1990a, 1990b, 1992). Since 1990, further decay of the stand has occurred, resulting in a small number of extra logs and snags every year.

2.3 Methodology

In every country, about 200 dead beech trees have been selected, aiming at an equal distribution over 6 decay-stages (tab. 1) and 5 diameter-classes (15-30 / 30-45 / 45-60 / 60-75 / >75 cm DBH). Both logs (lying dead wood) and snags (standing dead wood) have been included. Large branches broken out of living trees are used as a substitute if small dead trees are lacking. Attention is also given to the canopy cover: both trees under closed canopy or lying in smaller and larger gaps have been selected.

Every tree has been subjected to a detailed description including DBH, location, range of decay-phases present, soil-contact, bark cover, light conditions and volume of different homogeneous compartments (log, crown, snag).

For each compartment, a detailed inventory of the botanic richness has been made. For logs, the root-plate has also been included and separately recorded. All vascular plants, bryophytes and lichens have been inventoried, and their cover percentage has been estimated.

Table 1. Description of the 6 decay stages used in the project (protocol Nat-Man, unpublished)

decay phases	bark	twigs and branches	softness	Surface	Shape
1	intact or missing only in small patches, cover more than 50%	present	hard or knife penetrates 1-2 mm	covered by bark, outline intact	Circle
2	missing or cover less than 50%	only branches (>3 cm) present	hard or knife penetrates less than 1 cm	smooth, outline intact	Circle
3	missing	missing	Begins to be soft, knife penetrates 1-5 cm	smooth or crevices present, outline intact	Circle
4	missing	missing	soft, knife penetrates more than 5 cm	large crevices, small pieces missing, outline intact	Circle or elliptic
5	missing	missing	soft, knife penetrates more than 5 cm	large pieces missing, outline partly deformed	flat elliptic
6	missing	missing	soft, partly reduced to mould	outline hard to define	flat elliptic covered by soil

For fungi the presence has been recorded for a selected number of groups : agarics s.l., gastromycetes, polypores s.l., Hericeales (5 genera), Gomphales (*Ramaria*, *Kavinia*), Corticiales p.p. (12 genera), larger Heterobasidiomycetes (5 genera), larger Pyrenomycetes (6 genera) and larger Discomycetes (9 genera).

For vascular plants and mosses the survey was done in July, for fungi, three samplings were carried out (1 in summer, 2 in autumn). Only larger tree parts, with a diameter of 10 cm or more, have been taken into consideration. No distinction was made between *Dryopteris carthusiana* and *Dryopteris dilatata* as many individuals on the logs were not fully developed.

2.4 Nomenclature

Vascular plants: Lambinon et al. (1998); Bryophytes: Dirkse et al. (1999); Lichens: Aptroot et al. (1999); Fungi: Arnolds et al. (1995).

3 Results

In our study site, 195 trees were selected, representing almost 1200 m³ of coarse woody debris. An ideal equal distribution over the different diameter and decay classes was not possible, due to the low presence of decay phases 5 and 6 (tab. 2).

Table 2. Distribution of the selected trees over diameter and decay classes.

Decay-phase	Diameter (DBH)						Total
	15-29 cm	30-44 cm	45-59 cm	60-74 cm	75-89 cm	≥90 cm	
1	5	6	6	2	0	2	21
2	8	4	2	1	2	7	24
3	11	13	15	20	29	17	105
4	7	9	2	3	6	8	35
5	2	4	1	1	1		9
6		1					1
Total	33	37	26	27	38	34	195

There is an overrepresentation of heavy logs of decay stage 3, as most of the objects were fully-grown trees, uprooted during the storms in January and February 1990. Decay phase 6 was almost absent at the site, especially in the large volume classes. Therefore, has not been considered any further in this paper. It should be noted that decay phases of the selected trees presented in van Dort & van Hees (2002) have been corrected here after comparison with other participants in the project (they were often overestimated).

3.1 Vascular Plants

The inventory of vascular plants on the logs and uprootings resulted in a total of 48 plant species (van Dort & van Hees 2002). Except for a few errant seedlings, almost no vascular plants occur on freshly fallen logs. However, already starting from decay phase 2, but especially from phase 3 onwards, many species have been starting to grow on the decaying logs. Table 3 suggests that the total species number decreases after decay stage 4 . However this decrease is mainly due to the lower volume of investigated logs. There is an obvious succession in plant species composition depending on the decay phase of the log, as illustrated in table 4 for the 10 most frequently found species.

Table 3. Number of plant species found on the logs.

Decay-phase	1	2	3	4	5(&6)	total
# logs	21	24	105	35	10	195
# species	4	20	35	37	17	48
mean # species/log	0.2	1.9	3.8	4.8	4.0	

Data on plant species on the logs can be compared to another dataset, from a detailed inventory of vascular plants in a 7,5 ha core zone within the reserve, in which all present logs were investigated, together with a full inventory of the ground flora (De Keersmaeker et al. in prep.). During that research an even higher number of species was found on logs and root-plates (58 secies). Of a total of 85 plant species found within the core zone, 15 species were exclusively found on logs and/or root-plates and uprooting systems (tab. 5).

Table 4. Presence/absence (% of all logs where species is present) for the 10 most abundant vascular plant species.

Decay-phase	1	2	3	4	5	Total (%)
<i>Dryopteris carthusiana</i> + <i>dilatata</i>	0	21	59	66	67	49
<i>Oxalis acetosella</i>	5	29	54	57	22	45
<i>Fagus sylvatica</i>	0	17	44	40	0	33
<i>Urtica dioica</i>	0	8	22	31	44	21
<i>Carex remota</i>	5	21	17	29	33	19
<i>Lamium galeobdolon</i>	0	13	17	31	44	18
<i>Rubus fruticosus</i>	0	13	19	29	11	17
<i>Juncus effusus</i>	5	8	22	17	0	16
<i>Milium effusum</i>	0	4	16	14	33	13
<i>Epilobium tetragonum</i>	0	8	16	14	0	12

Table 5. Presence of vascular plant species on different substrates in a 7.5 ha core zone of the Forest Reserve Kersselaerspleyn.

Vascular plants	Number of species	Exclusive species
Species on Logs	27	4
Species on Root-plates	33	9
Species on Logs and rootplates	58	2
Species on undisturbed soil	70	39
Total number of species	85	

3.2 Mosses and Lichens

A total of 52 species of bryophytes were found on the logs. Lichens seem to be very scarce on the logs, with only 4 species found (van Dort & van Hees 2002). Most common species of mosses were *Brachythecium rutabulum*, *Hypnum cupressiforme*, *Lophocolea heterophylla* and *Brachythecium salebrosum*. Presence of the most common species on the logs, and their distribution over different decay stages are given in table 7.

Table 6. Number of bryophyte and lichen species depending on the decay stage of the log.

Decay-stage	1	2	3	4	5 (&6)	Total
#logs	21	24	105	35	10	195
#mosses+lichens	26	35	50	39	27	56
mean # species/log	2.4	6.0	9.6	8.5	7.3	

Table 7. Presence/absence (% of all logs where species is present) for the 10 most abundant bryophytes.

Decay-phase	1	2	3	4	5	Total (%)
<i>Brachythecium rutabulum</i>	57	92	97	100	100	93
<i>Hypnum cupressiforme</i>	29	75	90	91	56	80
<i>Lophocolea heterophylla</i>	5	46	78	77	67	65
<i>Brachythecium salebrosum</i>	5	42	75	71	67	63
<i>Eurhynchium praelongum</i>	5	25	73	80	78	61
<i>Atrichum undulatum</i>	14	33	64	66	56	54
<i>Mnium hornum</i>	10	46	56	63	56	51
<i>Herzogiella seligeri</i>	0	29	57	43	44	44
<i>Polytrichum formosum</i>	5	21	54	43	33	42
<i>Bryum capillare</i> s.l.	5	25	40	26	11	30

The project revealed some rare and remarkable species. *Drepanocladus uncinatus* had not been previously reported from the Zoniën forest (Sotiaux et al. 1999). For other species, new localities within the forest are provided. Compared to an unpublished species list for the forest reserve by Sotiaux & Vanderpoorten (1999), made within the framework of their inventory concerning the whole forest (Sotiaux & al. 1999), 21 of the now recorded species are new to the reserve. Remarkable findings are *Rhytidiadelphus loreus*, *Zygodon viridissimus*, *Nowellia curvifolia* and *Ptilium pulcherrimum* (van Dort & van Hees 2002).

3.3 Fungi

Up to now, 244 species have been identified, of which 193 species belong to the selected groups of the project. However, the estimated species number growing on the logs is supposed to be much higher (300-350 spp).

193 species are more or less strict lignicolous saprophytes, of which 33 are polypores. Three species are new records for Flanders, viz. *Callistosporium luteoolivaceum*, *Mycena picta*, and *Nemania chestersii*. Some rare species for this region include a.o. *Ceriporiopsis pannocincta*, *Coprinus spelaiophilus*, *Henningsomyces candidus*, *Hohenbeuthelia auriscalpium*, *Parthenope pilatii*, *Pluteus insidiosus* and *Psathyrella laevissima*. The most common species are *Eutypa spinosa* (present on 82% of studied trees), *Rickenella fibula* (67%, associated with bryophytes), *Xylaria hypoxylon* (65%), *Ustulina deusta* (64%), *Hypoxylon fasciculare* (61%), *Armillaria lutea* (52%), *Pluteus cervinus* (52%), *Ganoderma lipsiense* (51%), *Physisporinus vitreus* (48%), *Mycena haematopus* (47%), en *Psathyrella piluliformis* (47%). The distribution of these most common species over the different decay phases is given in table 8.

Table 8. Presence/absence (% of all logs where species is present) for the most abundant fungal species.

Decay-phase	1	2	3	4	5	Total (%)
<i>Eutypa spinosa</i>	33	88	94	71	89	82
<i>Rickenella fibula</i>	43	25	81	89	67	67
<i>Xylaria hypoxylon</i>	43	96	66	54	67	65
<i>Ustulina deusta</i>	5	50	74	80	56	64
<i>Hypoxylon fasciculare</i>	19	54	72	49	89	61
<i>Armillaria lutea</i>	14	21	62	66	56	52
<i>Pluteus cervinus</i>	5	29	61	74	33	52
<i>Ganoderma lipsiense</i>	10	46	62	57	11	51
<i>Physisporinus vitreus</i>	5	25	57	60	67	48
<i>Mycena haematopus</i>	5	21	63	51	11	47

4 Discussion

Freshly fallen logs (decay stages 1 and 2) are rarely colonised by vascular plants. Starting from stage 3 however, many species start to colonise the logs. Preferences for certain decay-phases are strongly dependent on the species. Some plant species seem to have no clear preference for certain decay-phases, like *Dryopteris*-species (i.e. *D. carthusiana* + *dilatata*), and *Lamium galeobdolon* (starting from stage 3). It should be mentioned however that *Lamium galeobdolon* produces stolons and therefore it is not always clear if individuals have germinated on the logs (or have spread vegetatively from the ground surface). Other species do have a clear preference for highly decayed wood (*Urtica dioica*, *Carex remota*, *Milium effusum*), or an intermediate stage of decay (*Oxalis acetosella*, *Juncus effusus*, *Fagus sylvaticus*) and – in most cases – clearly have germinated on the logs. Further analysis and comparison to the results from the other countries should provide more solid grounds for these assumptions.

Species that were exclusively found on logs were *Mycelis muralis* and *Crepis* sp. (cf. *biennis/capillaris*). Exclusive for rootplates were species that are mostly associated with relatively dry and nutrient-poor open vegetations like clearcuts and grasslands (*Carex ovalis*, *Carex pallescens* and *Hypericum humifusum*) or mesophilous continental forest types (*Luzula luzuloides*).

Other surprising species found almost exclusively in uprooting-systems are *Melica uniflora*, and *Rubus idaeus*. *Melica uniflora* is associated with neutral to moderately acid soil types (reaction-figure 6 according to Ellenberg et al. 1992) without thick litter layer, unlike the ones usually found in the Zoniën Forest. Soil disturbance, correlated with the uprooting of trees, brings mineral soil which is less acid (less lessivated layers from the deeper soil) to the surface. This feature might explain the occurrence of this species in an acid environment. According to Weeda & al. (1987) in canopy gaps *Rubus idaeus* is a pioneer species that is promoted by intensified litter mineralisation.

Unlike vascular plants, moss species also colonize the first decay stage: almost half of the species already occur within a few months or years after the blowdown or breakage of the stem (table 6 and 7). However, many of these species are already present on the living tree. *Brachythecium rutabulum* and to a lower extent also *Hypnum cupressiforme*, *Atrichum undulatum* and *Mnium hornum* are the most commonly found species in decay stage 1, but have their optimum in stage 3. Species like *Lophocolea bidentata*, *Plagiothecium nemorale* and the lichen *Cladonia coniocraea* only occur starting from decay stage 3. *Dicranum tauricum* however has a clear preference for fresh to moderately decayed wood.

The most common bryophytes in the forest reserve of Zoniën belong especially to the *Bryo-Brachythecion*, which is typical for half-decayed, neutral to basic wood (van Dort & van Hees 2002). This is quite remarkable considering the acid topsoil. A possible explanation would be that the fully-grown trees are able to extract the basic cations from the calcarous sandy subsoil, thus resulting in neutral to basic composition of the wood. Further comparative chemical analysis of the wood should evaluate this assumption.

A small number of fungal species seems to show preferences for particular parts of the dead trees (such as *Clitopilus hobsonii*, almost exclusively found on snags, or *Melanamphora spinifera*, on bark at the base of the trees), but the main ecological factor is related to the decay phase, as already demonstrated by Heilmann-Clausen (2001).

During the initial phase of decay, the development of the fungal community is quite predictable as far as species composition is concerned : it includes primarily two types : endophytic latent invaders (like *Hypoxylon fragiforme*) and unspecialized opportunists like *Cylindrobasidium evolvens* or *Schizophyllum commune*. Decay-phase 2 is characterized as the *Trametes*-phase, where the fungal community is dominated by white rotters such as *Trametes versicolor*, *T. gibbosa* (in shaded sites), *T. hirsutum* (in sunny sites), *Bjerkandera adusta*, *Datronia mollis*, *Phlebia radiata*, and *Trametes* spp. Decay phases 3-4 only develop after a long period of decay and have a diverse species composition with active wood desiccators (*Eutypa spinosa*, *Ustulina deusta*) and mycelial cord forming basidiomycetes (such as *Armillaria lutea*, *Hypholoma fasciculare*, *Lycoperdon pyriforme*). Later in the development, species such *Ascocoryne cylichnium*, *Mycena* spp., *Pluteus* spp., *Psathyrella piluliformis*, *Simocybe* spp.; and on moist parts *Peziza micropus*, *Scutellinia scutellata* and slime moulds also begin to occur. Decay phases 5-6 are characterized by the arrival of unspecialized litter saprophytes and ectomycorrhizal fungi.

Rare or presumed locally threatened species have been more frequently found on the largest logs, with decay phase 3-4. Valuable localities for fungi associated with *Fagus* logs can also be identified using a list of 42 indicator species developed for Denmark (Heilmann-Clausen & Christensen 2000). Only 32 of these species are recorded from Flanders, and 17 of these have been reported from the Zoniënwoud (Vanholen & De Kesel 2000). Upto now, 14 of these indicators have been traced at the study site, indicating it to be, at least to Belgian standards, a very valuable

locality for fungi of large beech wood. Lacking indicator species often represent weakness parasites of wounded trees (e.g. *Inonotus cuticularis*), which is due to the fact that the site has been left unmanaged for only a relatively short period. It is expected that the number of this indicator species will rise when more overmature trees die back, and the different decay phases of the logs will be more equally represented.

5 Conclusion

The preliminary results of this research have already provided clear indications that dead wood of beech can represent an important and unique substrate, not only for fungi, but also for mosses and vascular plants. Lichens however are almost absent.

Especially large logs that are in an advanced stage of decay, and the uprooting system provide a very specific substrate that allows specific plant and fungi species to develop. Some of these are not always associated with closed forest stands, but find in these conditions a new niche to grow. Over 20% of the vascular plants found in the forest reserve were exclusively found on the logs and root-plates of windblown trees. The diversity of moss species is remarkably high, and is almost exclusively related to the logs and uprootings.

The first results for fungi demonstrate the extreme importance of dead wood, especially very large logs, in different decay stages.

These preliminary results suggest that the importance of dead wood for the overall botanic diversity of forest stands is perhaps even higher than commonly assumed, and not only essential for Fungi, but also for vascular plants and mosses. Therefore, the presence of dead wood in forest stands should more than ever be considered as an essential aspect of the forest ecosystem and diversity and should be incorporated in the management of all forest stands, also outside reserve areas.

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Methodology for intensive monitoring of forest dynamics in strict forest reserves in Flanders (northern Belgium)

Kris Vandekerckhove, Luc De Keersmaecker & Hans Baeté

Institute for Forestry and Game Management, Gaverstraat 4, B-9500 Geraardsbergen, Belgium
kris.vandekerckhove@lin.vlaanderen.be

Abstract. – *The standard methodology for monitoring of strict forest reserves in Flanders, consists of a combination of grid-based nested plots and a core area. This methodology complies with the standards internationally set for the monitoring of forest vegetation dynamics in strict forest reserves. Moreover, the results of the circular plots are compatible with the datasets from the Flemish Forest Inventory. This methodology therefore provides possibilities for detailed description and analysis of processes within the forest stand, a decent description of the forest reserve as a whole, and comparisons with other managed and unmanaged forests in Flanders and Europe. In order to illustrate the possibilities of the methodology, some results from the forest reserve Kersselaerspleyn (Zoniënwoud) are presented. The accuracy of the dendrometric results from circular sample plots is tested by comparing them to full-inventory data. The possibilities to study relationships between herbal layer and tree layer in the core zone are also evaluated. The results from the core zone showed clear links between structural diversity of this beech forest and floristic diversity, with low diversity in large storm gaps and regeneration groups, and a much higher species richness in the old stands with small gaps. Especially uprootings created new opportunities for light-demanding perennial species.*

Samenvatting. – *Methodologie voor intensieve monitoring van bosdynamiek in strikte bosreservaten in Vlaanderen. De standaard methodologie voor monitoring in strikte bosreservaten in Vlaanderen bestaat uit een combinatie van een raster met geneste proefvlakken en een kerngebied. Deze methode volgt internationale standaards voor de monitoring van de dynamiek van bosvegetaties in strikte bosreservaten. Bovendien zijn de resultaten van de cirkelvormige proefvlakken uitwisselbaar met de datasets van de Vlaamse Bosinventaris. De methode biedt mogelijkheden voor een gedetailleerde beschrijving en analyse van processen in het bosbestand, voor een goede beschrijving van het bosreservaat als geheel en voor het vergelijken van beheerde en onbeheerde bossen in Vlaanderen en Europa. Om de mogelijkheden van de methode te illustreren, worden enige resultaten van het bosreservaat Kersselaerspleyn (Zoniënwoud) voorgesteld. De nauwkeurigheid van de dendrometrische resultaten van de cirkelvormige proefvlakken wordt getest door ze te vergelijken met de gegevens van de volledige inventaris. De mogelijkheden om de relaties tussen kruid- en boomlaag te bestuderen in het kerngebied worden ook geëvalueerd. De resultaten van de kernzone toonden een duidelijk verband aan tussen de structurele diversiteit en de floristische diversiteit van dit beukenbos, met lage diversiteit in grote windvallen en in regeneratiebestanden, en een hogere soortenrijkdom in oude bestanden met kleine open plekken.*

Voor al omgevallen bomen zorgden voor mogelijkheden voor lichtminnende overblijvende soorten.
Vertaald door de redactie.

Résumé. – Méthodologie de surveillance intensive de la dynamique forestière dans les réserves forestières intégrales de Flandre (nord de la Belgique). *La méthodologie standard pour la surveillance de réserves forestières intégrales en Flandre consiste en une combinaison d'une grille de placeaux emboîtés et d'une zone-noyau. Cette méthodologie se conforme aux standards établis au niveau international pour la surveillance de la dynamique forestière dans les réserves forestières intégrales. En plus, les résultats de ces placeaux circulaires sont compatibles avec les collections de données de l'Inventaire Forestier Flamand. Cette méthodologie fournit dès lors des possibilités de description et d'analyse détaillées des processus dans la station forestière, une description convenable de la réserve forestière comme unité et des comparaisons avec d'autres forêts, aménagées ou non, de Flandre et d'Europe. Afin d'illustrer les possibilités de la méthodologie, quelques résultats de la réserve forestière "Kersselaerspleyn" (Forêt de Soignes) sont présentés. La pertinence des résultats dendrométriques tirés des placeaux circulaires est testée en les comparant à des données d'inventaires complets. Les possibilités d'étude des relations entre strate herbacée et strate arborescente dans la zone-noyau sont également évaluées. Les résultats obtenus dans la zone-noyau ont montré un lien clair entre la diversité structurale de cette forêt de hêtre et la diversité floristique, avec une faible diversité en espèces dans les zones de chablis de tempête importants ou dans les aires de régénération, et une richesse en espèces bien supérieure dans les stations âgées à petites trouées. Les chablis en particulier créent de nouvelles opportunités pour les espèces héliophiles vivaces. Traduit par la rédaction.*

Key words: *methodology, monitoring, forest dynamics, forest reserve, Fagus sylvatica, Pteridium aquilinum, Flanders*

Abbreviations: *DBH, Diameter at Breast Height (tree diameter at 130 cm height); LAI, Leaf Area Index.*

Nomenclature: *Lambinon & al. (1998).*

1 Introduction

Strict forest reserves are forest areas that have been left unmanaged for spontaneous development. In Flanders, the first forest reserves were designated in 1995 and since then, a network of approximately 1700 ha of forest reserve has been established, the great majority of which being strict reserves. In a European context, strict forest reserves are mainly conceived for the study of spontaneous forest dynamics (Parviainen et al. 2000). Forest reserves in Flanders additionally have an important nature conservation function (Vandekerckhove 1998).

As stated by many authors, strict forest reserves are considered as an important information source for close-to-nature forestry outside the reserves (Leibundgut 1966; Mayer 1978; Thomasius 1992; Parviainen et al. 2000). This requires reliable dendrometric and vegetation data that are comparable both over time and amongst one another. Therefore, a monitoring methodology was developed that had to comply with European standards set by COST-action E4 (Hochbichler et al. 2000), and is also in accordance with the methodology of the Flemish Forest Inventory, thus allowing both comparisons with other forest reserves in Europe and other forests in Flanders, both managed and unmanaged. The aim was to develop a methodology that not only produces reliable and comparable dendrometric and floristic data, but also provides possibilities for research into

ecological processes within the forest stands. In this paper, the development of the methodology is described and discussed, and is subsequently illustrated by presenting some results from the monitoring of the forest reserve of Kersselaerspleyn (Zoniënwood).

2 Development of the methodology

2.1 Aims

The global aim is to monitor the development of the vegetation in forests that are deliberately left unmanaged. The sampling method should provide knowledge on the development of the reserve as a whole, as well as better insight in the processes triggering the development.

2.2 Material and methods

The development of a standard methodology for the monitoring of strict forest reserves in Flanders was based on experiences in other countries, the guidelines of the European COST-action E4 (Hochbichler et al. 2000) and some own preliminary studies (Van Den Meersschaut & Lust 1997a & b; Van Den Meersschaut et al. 2000). Many European countries have a long tradition in monitoring of strict forest reserves, and have developed detailed methodologies and guidelines to do so.

From the 1950's onwards, elaborate research programmes have been set up in central Europe, using full inventories and strip transects to study the distribution and structure of different developmental stages of strict forest reserves (Leibundgut 1959, 1981; Mayer 1966, 1967; Mayer et al., 1987; Mlinsek 1970; Korpel 1995; Prusa 1985). Measurements have almost exclusively been focused on trees and dead wood (for the latter not so much focusing on the necromass itself, but on the die-back-mechanism of living trees, the so-called mortality).

From the 70's onwards, full inventories have been abolished and replaced by sampling methods based on circular sampling plots within a grid system, or studies of strip transects or core zones or a combination of both (Albrecht 1990; Althoff et al. 1993; Broekmeyer, 1995; Bücking 1990; Bücking et al. 1986; Kätzler 1984; Kirby et al. 1996; Koop, 1989; Mountford et al. 1999; Peterken & Backmeroff 1988; Projektgruppe Naturwaldreservate 1993). The use of sample plots allowed to include other important aspects in the recordings, such as the analysis of soil and ground vegetation, that are important for the analysis and explanation of forest dynamics. In recent times the scope of the monitoring research has further widened to include important topics that affect nature conservation: inventories and surveys of populations of fungi, birds, bats, saproxylic invertebrates and red-list species and their relations to the forest dynamics are increasingly integrated into the monitoring programmes (Bücking, 1996; Rauh, 1993; Köhler, 1996; Winter 1999).

From the analysis of all these documents, following requirements were drawn (followed by the principle reference):

- An adequate monitoring of the reserve should involve at least the basic dendrometric measurements (species, DBH, height of upper storey, regeneration), combined with vegetation relevés. Analysis and typology of the soil should also be done, at least once at the beginning of the monitoring (Hochbichler et al., 2000).
- A standardised grid of sampling plots will produce reliable data on the development of the reserve as a whole, while as the core area or transect will provide more detailed information on the ecological processes that trigger the spontaneous development, and the interactions between tree layer, soil and ground vegetation. It is therefore advisable to apply a combined sampling, with both sample plots and core areas, in order to cover both scales (Van Den Meersschaut & Lust 1997a).
- The sample plots are preferably round plots (less edge effects and uncertainty on the relocation), with a minimum size of 500 m². Within this plot, square or round subplots should be established for measurements on regeneration and ground vegetation (Hochbichler et al. 2000).
- In order to produce reliable data for the whole reserve (accuracy levels of 5 to 10 %) on basal area, species composition and stem number, based on data from the sampling plots, a sampling intensity of at least 15-20 % is needed (Van Den Meersschaut et al. 2000).
- Core areas should at least have a surface of 1 ha. They consist of a number of juxtaposed strip transects, forming a square or rectangle, with a minimum width of two times the tree height (60-80 m) (Koop 1989; Albrecht 1990).
- A combination of the measurements with analysis of aerial photographs is recommended, in order to cover particular developments outside the plots and in the surroundings of the reserve (Hochbichler et al. 2000).
- Measurements should be repeated at least every 10 years. Long time experiences show that the interval of 10 years is long enough to produce relevant changes, and yet frequent enough not to overlook important developments (Koop 1989; Hochbichler et al. 2000).
- Additional monitoring of other organisms (fungi, birds, insects,...) is promoted, if done in a standardised way and linked to the sampling network, thus providing a better insight into the ecological processes and their effects on species composition and diversity and vice versa (Albrecht, 1990; Bücking, 1996).

2.3 Results

This results in a methodology based on permanent plots, combining a grid of sample plots with a core area (fig 1). The grid system consists of circular nested plots of 1000 m², covering 20% of the total area. In these plots basic measurements are done on woody vegetation and herbaceous layer (see fig 1). These measurements are combined with soil samples, light measurements and/or fish-eye images, and aerial photographs if available.

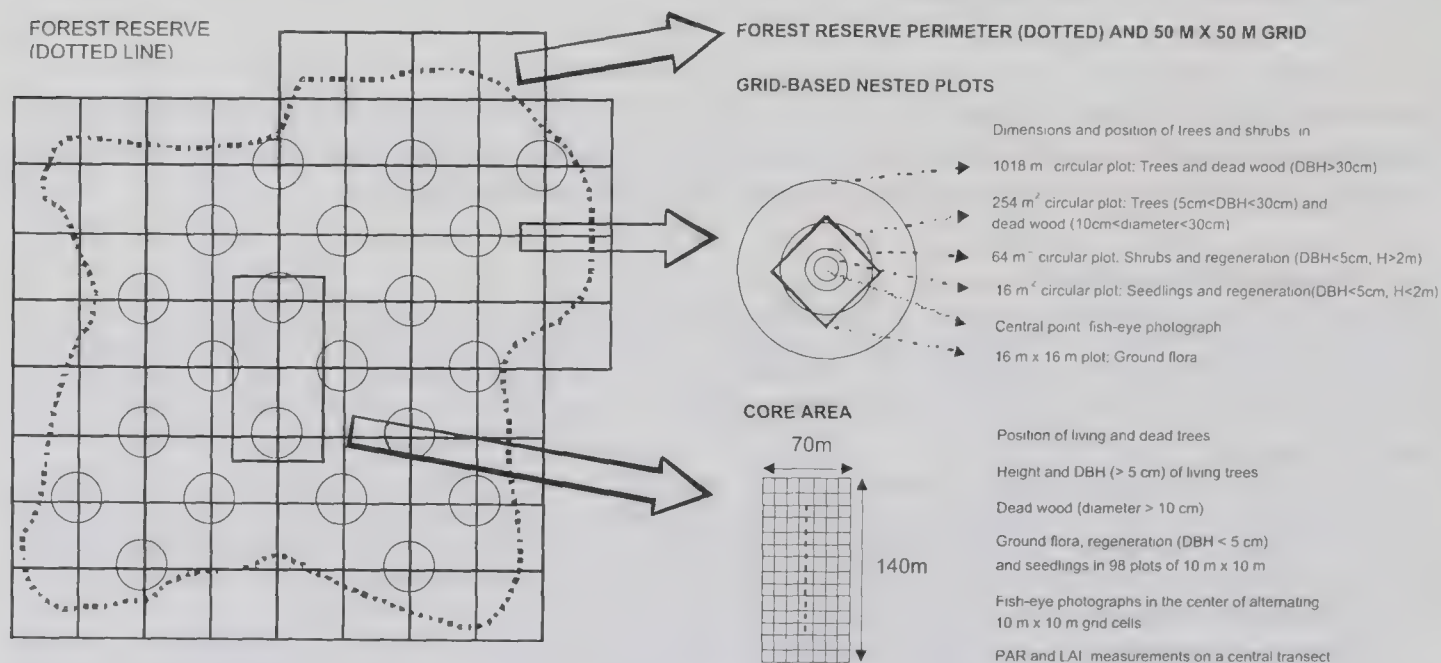


Figure 1. Design of the standard methodology of forest reserve monitoring: a combination of grid-based nested plots and a core area

The core area is located in the centre of the reserve and aims for more intensive measurements. The standard dimensions of the core area are 70x140 m. All trees above 5 cm DBH are identified, positioned and measured, vegetation and regeneration is mapped in detail in 10 m x 10 m subplots, soil and light conditions are analysed. All plot and tree positions are measured by Total Station, and the data are imported into a GIS-environment, allowing geographical analysis.

The methodology is flexible, in this sense that it can be adjusted to local conditions, be it that the minimal requirements are respected (see below).

2.4 Discussion

The monitoring methodology is similar to the one used in the Netherlands, combining the advantages of both circular samples and a core zone. The circular plots are mainly to be considered as pure samples, allowing a global overview on the development of the area as a whole: how is the distribution of tree species, stem number, basal area, vegetation types and species, etc. of the reserve. However, as these plots are permanent, they can also be considered as individual, be it small permanent plots, allowing precise analysis of future changes on the plot area. For detailed analysis, they are less useful, as the set of measurements and the size of the plot required for that purpose, would make the set-up too labour-intensive. The need for more detailed data in order to allow analysis of the processes and interactions triggering the development, is covered by the information from the core area. The detailed information provided here on ground cover, tree positions, crown parameters, soil properties, light measurements, etc. allow for instance a robust analysis of multilateral influences between soil, woody layer and ground vegetation.

The plot design and the methodology of the measurements in the circular plots are identical to the ones in the Flemish Forest Inventory, thus allowing immediate comparison. They also comply with the international requirements, so international data comparison is also possible. The size and measurements in the core area are in accordance with the SILVI-STAR method developed by Koop (1989) and used in the Dutch forest reserves programme, thus also providing opportunities for co-operation.

Some preliminary results from the core area in the forest reserve Kersselaerspleyn are given below and provide a first impression of the potential of the methodology.

This monitoring programme is quite intensive and elaborate. It doesn't only aim at a global assessment of the diversity of the site, using biodiversity-indicators, as proposed for forests by Vandekerckhove et al (2002), and for urban parks by Hermý & Cornelis (2000). The programme also aims at detailed descriptions of status and dynamics of the forest structure and analysis of the driving forces of these ecological processes, and their effects on the ecosystem and specific organisms. This requires detailed and time-consuming measurements and analysis. For an average sized reserve (50 ha) the whole process of set-up, field measurements and processing the data covers about 500 working days.

3 Illustration of the methodology using some preliminary results from the core area of the forest reserve Kersselaerspleyn (Zoniënwood)

3.1 Material and methods

The forest reserve of Kersselaerspleyn has a size of 98 ha and is located in the centre of the forest of Zoniënwood (4300 ha), south of Brussels (fig 2). A description of the area and its management history has been given in another paper in this volume by Vandekerckhove et al (2003).

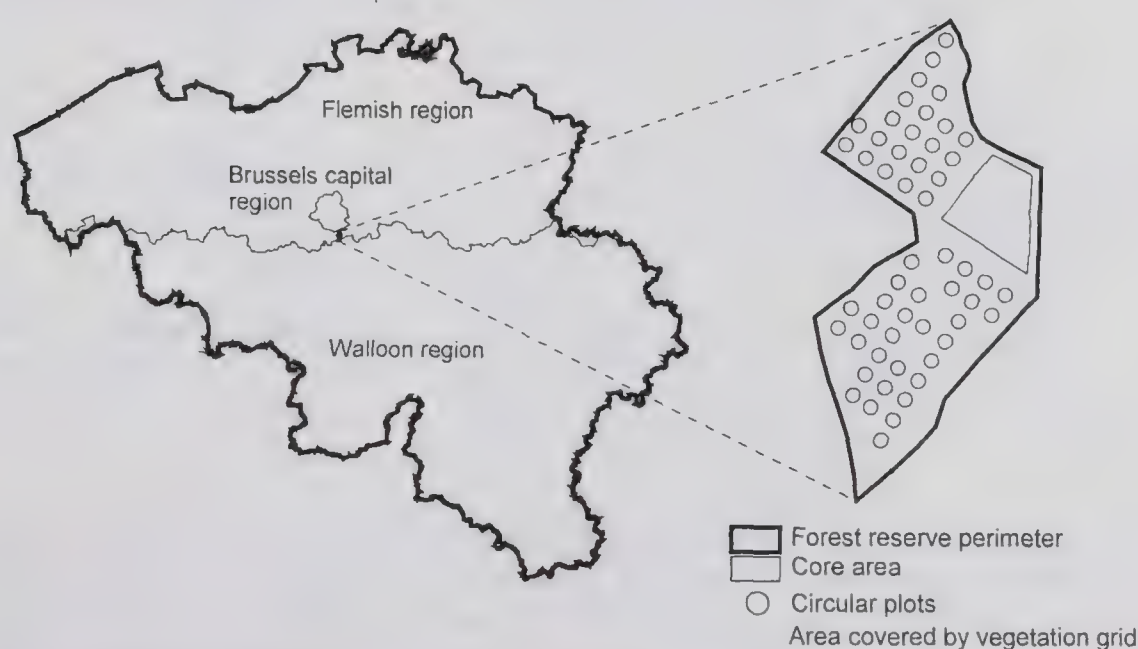


Figure 2. Location of the forest reserve Kersselaerspleyn south of Brussels, with a detailed view of the sample design within the forest reserve.

In the forest reserve Kersselaerspleyn (Zoniënwood) the standard methodology was slightly altered. As stated, the methodology is flexible and allows some alterations in function of the local conditions. The size of the circular plots was expanded to 2000 m² as tree dimensions and distances are extraordinary high in this site. Size extension was necessary in order to comply with the basic principles of Kramer & Akça (1982), Richter & Grossmann (1959) and Spurr (1952) pointing out that an individual plot should at least contain respectively 25 to 30, 12 to 14 or 20 to 30 trees per plot. By widening the grid to 100 x 100 m, the sample size of 20% could be respected. Also the core area was considerably larger than required, covering 10.5 ha in stead of 1 ha. This extension was based on the fact that detailed dendrometric information was available for this area from 1986 and 1990, providing opportunities for interesting detailed comparisons. Measurements in the core area were according to the prescriptions: all trees were positioned and measured, and

vegetation was mapped in 10 m x 10 m squares, using the decimal scale of Londo (1975). The vegetation grid covered a total area of 7.5 ha (fig 2). Gaps and woody cover were digitized from aerial photographs and derived from subplot data.

3.2 Results

3.2.1 Comparison of dendrometric data from circular plots and full inventory. In the core area, a full inventory and tree positioning was performed for all dead or living trees with DBH > 30 cm (fig 3). After loading the data into a GIS-system, simulations of different subsamples are easily made. By comparing a subsample coinciding with the sample of the grid of circular plots to the full inventory, it was possible to evaluate the accuracy of the sample, and thus give an estimation of the accuracy of the data gathered in the sample plots outside the core area (fig 4).

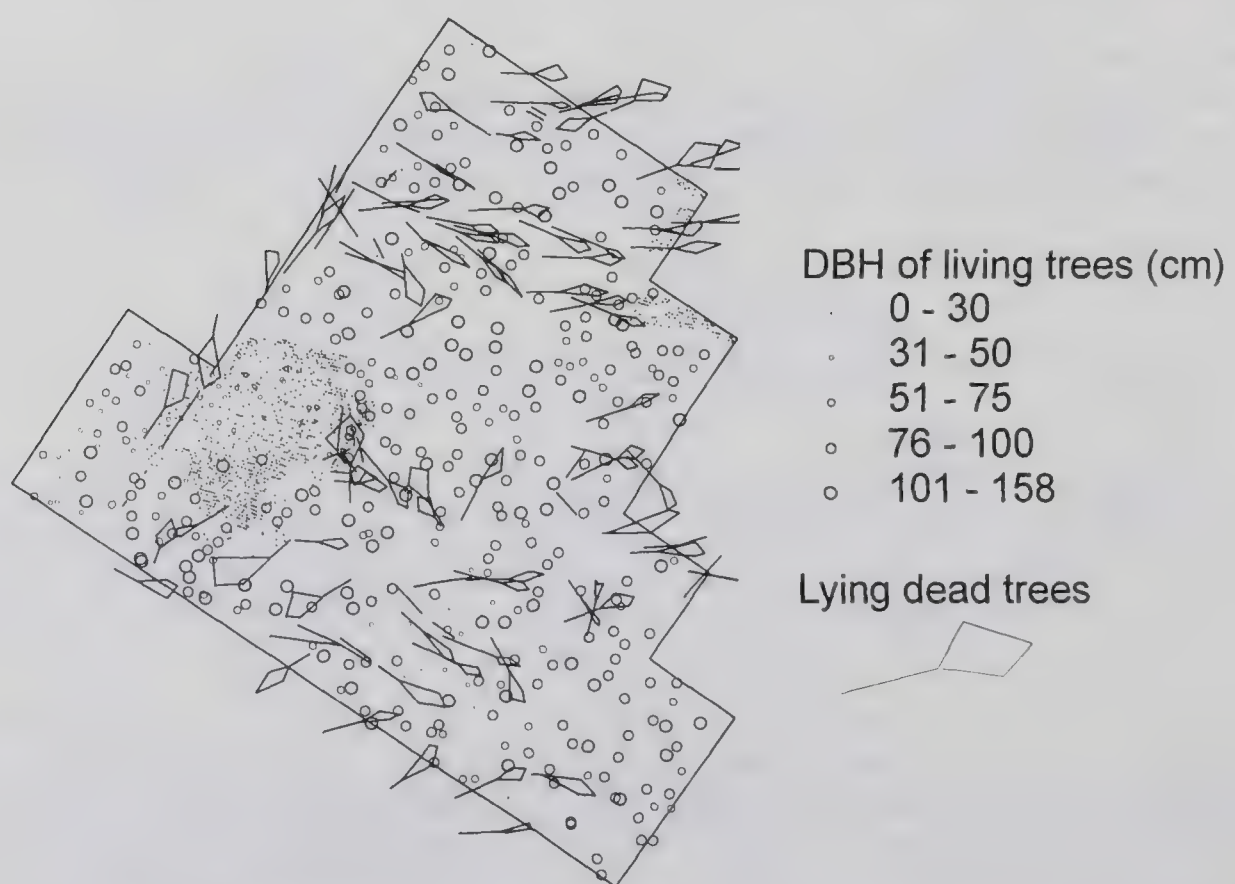


Figure 3. Map of the forest structure in the 7.5 ha core area of Kersselaerspleyn, with the position of lying dead trees and living trees divided into 5 diameter classes

The total area of circular plots in the core area amounted to 28% of the total area of the core zone, which is well above the sampling intensity of 15-20% recommended by Van Den Meersschaut & al. (2000). Comparison of the sample to the full inventory on dendrometric characteristics indicated that overall results were very similar. Calculations based on the circular plots slightly overestimated the total stem number and slightly underestimated the total volume. The error on the total stem number is comprised between 5 and 10 %, the error on the total volume is even below 1% (table 1). However, errors are more substantial for less frequent tree species, in casu oaks. Stratification of the calculations by taking into account the area of the circular plots situated in regeneration groups and in the large storm gap did not provide a more accurate picture. The heterogeneous structure of both areas might be responsible (table 1).

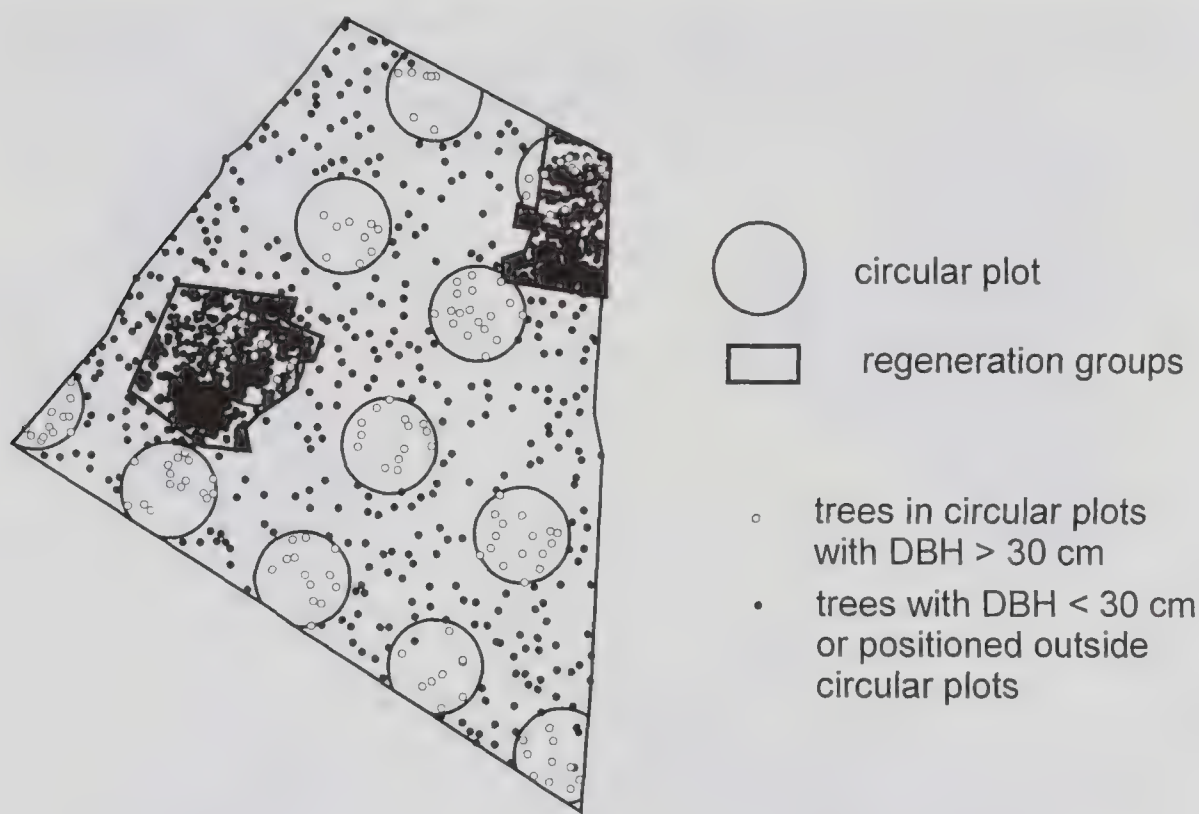


Figure 4. Tree positions in the core area, with an indication of trees within the circular plots and the perimeter of the regeneration groups

Table 1 : comparison of results for stem number and volume of living trees, using different sampling methods

	Stem number (ha ⁻¹)			Volume (m ³ /ha)		
	Beech	Oak	Total	Beech	Oak	Total
Circular plots	54.4	3.5	57.9	750.4	41.8	792.2
Circular plots, stratified	54.5	3.9	58.4	785.9	47.0	832.9
Full inventory	51.9	2.3	54.4	765.0	30.7	795.7

3.2.2 Relationships between woody layer and ground cover in the core area. The stand, in which the core area was established, consists almost exclusively of beech (*Fagus sylvatica*), planted in 1775, and left unmanaged since 1983. The canopy was closed until the gales of 1990 created gaps of varying size.

The detailed vegetation survey (750 plots of 10 m x10 m) revealed that the species richness is clearly linked to the canopy cover and gap sizes, as well as to the soil pH(KCl) (fig 5). The linear regression model, including both variables and their interaction, is highly significant. The relationship between forest structure and ground vegetation was elaborated in detail by De Keersmaecker et al. (2000).

The distribution of some characteristic plant species in the vegetation grid of the core area, in comparison with the tree cover, is illustrated by figure 6.

The floristic inventory indicated that dominance of Bracken (*Pteridium aquilinum*) is restricted to large gaps (>1 ha) as found in the north-west of the core area. Sample plots where Bracken was dominant showed a reduced species richness.

In the west of the core area, a planted 30-year-old regeneration group of beech of approximately 0.5 ha is present. Our inventory indicated that also here species diversity was very low. Moreover, also total vegetation cover was very low probably as a consequence of extreme

shading. Species that are common elsewhere in the core area like *Pteridium aquilinum* - a semi-shade plant (Ellenberg & al. 1992) that suffers from deep shading by beech (den Ouden, 2000) – but even species which are regarded to be very tolerant to deep shading by Ellenberg & al. (1992), such as *Dryopteris carthusiana* + *dilatata* and *Oxalis acetosella*, are almost absent in the regeneration group (fig 6).

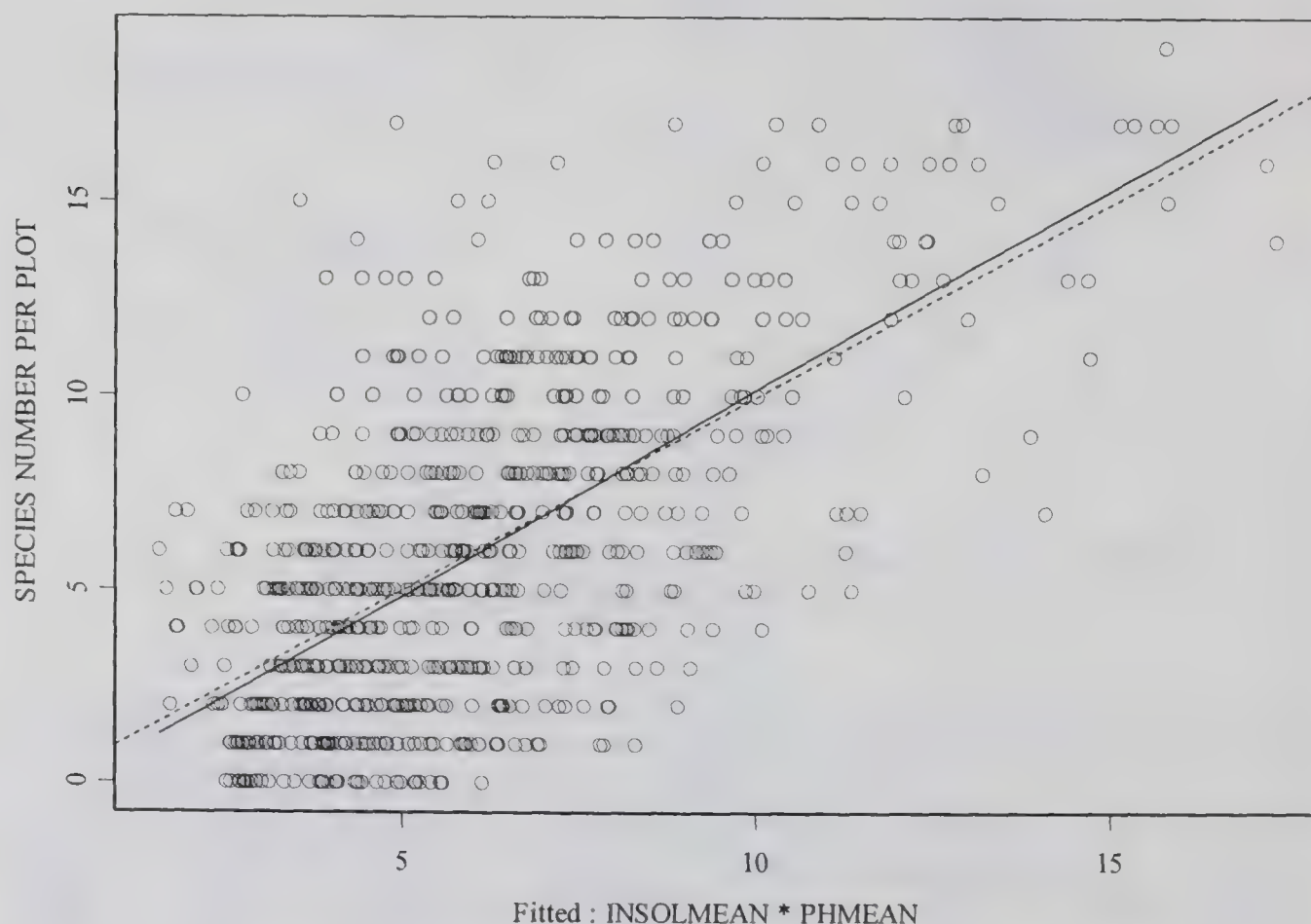


Figure 5. Linear regression model on species richness per 10 m x 10 m plot, with soil pH(KCl) and relative insolation as variables ($P < 0.001$; $R^2 = 0$)

Areas with small gaps however showed the highest species richness. Bracken is less dominant here, allowing other species to accompany, and a high range of moderate light conditions is present, creating good conditions for most forest plants. Moreover, the logs and rootplates in the small windthrow-gaps provide new habitats for quite a number of light-demanding species with a persistent seed bank, accounting for an important share of the species diversity (Vandekerckhove et al. 2003). *Carex pallescens*, *Rubus idaeus* and *Luzula luzuloides* for instance have a clear preference for mineral soil of uprootings.

3.3 Discussion

The results for the forest reserve Kersselaerspleyn illustrate that the developed methodology provides sample data that is detailed and accurate enough to give a full picture of the development of the reserve as a whole. Moreover the data from the core zone already have indicated that the developed monitoring methodology can be effective in providing better insight in processes and relations, and can produce guidelines towards a better conservation-oriented management in other forests outside the reserves. These preliminary results indeed suggest that structure and management of beech forests can be important determinants for floristic diversity. Both large gaps and large closed regeneration areas prove to be unfavourable environment for many forest plant

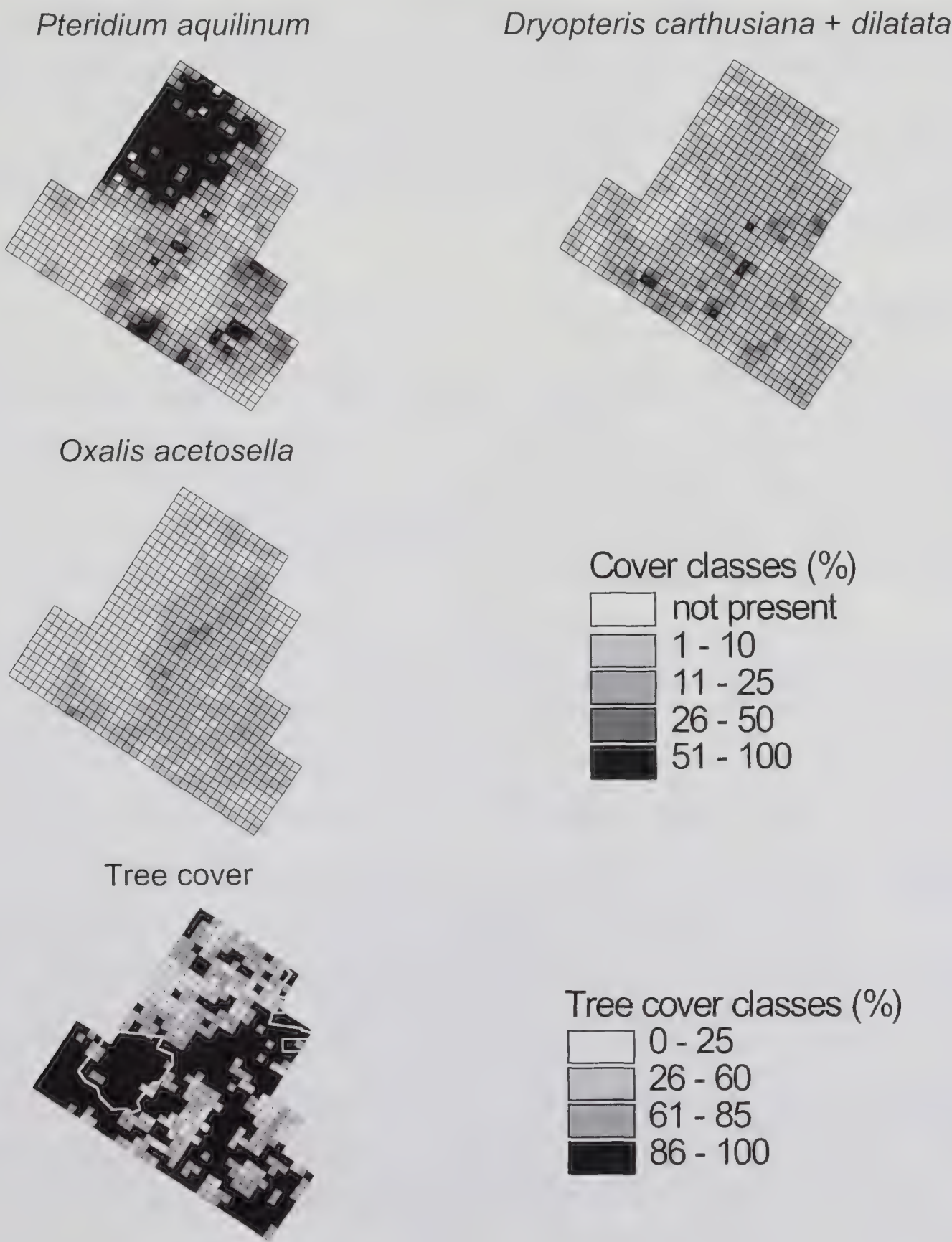


Figure 6. Distribution of *Pteridium aquilinum*, *Dryopteris carthusiana + dilatata* and *Oxalis acetosella* in the 7.5 ha core area of forest reserve Kersselaerspleyn, compared to the tree cover map (white line = location of large 30 year old artificial regeneration of beech).

species resulting in the disappearance of the species from this area. Most of these species have poor colonisation capacities and short-living seed bank. Large regeneration groups and relative short rotations can thus cause considerable decline of these species, and of the floristic diversity in beech forests. Small gaps and presence of logs and rootplates on the other hand prove to be favourable for most species and species diversity as a whole.

A forest management using shelterwood system, and leaving some of the uprooted trees untouched in the forest, is therefore preferred in order to conserve or even enhance the species richness of the ground vegetation.

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Conservation of the heritage of autochthonous woody plants in Flanders (Belgium)

Kristine Vander Mijnsbrugge

Institute of Forestry and Game Management, Gaverstraat 4, B-9500 Geraardsbergen, Belgium

Abstract. – *The growth sites of autochthonous trees and shrubs in Flanders have drastically been reduced. Obvious reasons are the processes of intensive forest exploitation and deforestation in the past centuries and more recently the scale enlargements in land use. Less known is the threat imposed on autochthonous genetic resources by the import of seeds from native species but of foreign provenance. Forest reproductive material is often grown from seeds that originate from Eastern and Southern Europe, where cheap labour is at hand. These plants may be less adapted to the Flemish growth conditions because of their remote origin. Spread of foreign genes can influence the genetic constitution of local autochthonous populations of the species. A first step towards the conservation and use of autochthonous trees and shrubs in Flanders is an inventory. It opens possibilities for in situ and ex situ conservation strategies. Next to a general outlining of the different aspects of this project, outstanding findings of the inventory on the genera Rosa, Crataegus and Quercus are discussed.*

Samenvatting. – *Bescherming van het erfgoed van autochthone houtachtige planten in Vlaanderen. Het aantal groeiplaatsen van autochthone bomen en struiken in Vlaanderen is drastisch afgenomen. Voor de hand liggende redenen zijn de intensieve bosexploitatie en ontbossing van de vorige eeuwen en meer recent de sterke schaalvergroting van het landgebruik. Minder gekend is de bedreiging waaraan het autochthoon genetisch materiaal blootstaat door de import van zaden van inheemse soorten van vreemde herkomst. Bosplantgoed wordt dikwijls gekweekt uit zaden afkomstig van Oost- en Zuid-Europa, waar goedkope werkrachten beschikbaar zijn. Dergelijke planten zijn mogelijks minder aangepast aan de Vlaamse groeivoorwaarden, omwille van hun vreemde herkomst. Verbreiding van vreemde genen kan de genetische samenstelling van lokale autochthone populaties van de soort beïnvloeden. Een eerste stap naar bescherming en gebruik van autochthone bomen en struiken in Vlaanderen is een inventaris. Dit opent mogelijkheden voor in situ en ex situ beschermingsstrategieën. Naast een algemene voorstelling van de verschillende aspecten van het project, worden een aantal uitzonderlijke vondsten bij de inventaris van de genera Rosa, Crataegus and Quercus besproken. Vertaald door de redactie.*

Résumé. – *Conservation de l'héritage en plantes ligneuses autochtones de Flandre. Les sites de croissance d'arbres et arbustes autochtones de Flandre ont été réduits de façon drastique. Des raisons évidentes en sont les procédés d'exploitation forestière intensive et la déforestation au cours des siècles passés, et plus récemment, l'accroissement important de l'utilisation des sols. Un phénomène moins connu est la menace qui pèse sur les ressources génétiques autochtones à la suite de l'importation d'espèces indigènes mais provenant de pays étrangers. Les pépinières*

forestières sont souvent issues de graines importées d'Europe orientale et méridionale, où la main-d'oeuvre est bon marché. Ces plantes, à cause de leur origine lointaine, peuvent être moins bien adaptées aux conditions de croissance en Flandre. La dispersion de gènes étrangers peut influencer la constitution génétique des populations autochtones de l'espèce. La première étape vers la conservation et l'utilisation des arbres et arbustes autochtones de Flandre est d'en faire l'inventaire. Cela ouvre des possibilités de stratégies de conservation in situ et ex situ. A côté d'une esquisse des différents aspects de ce projet, des trouvailles remarquables dans l'inventaire des genres Rosa, Crataegus et Quercus sont commentées. Traduit par la rédaction.

Key words: *genetic diversity, gene banks, in situ conservation, ex situ conservation, seed orchards, Rosa, Crataegus, Quercus.*

1 Introduction

1.1 Some definitions: autochthonous versus native

Since the last ice age, woody plants in Europe have been migrating from their refugia along the Mediterranean Sea towards the North. Populations got adapted to local and regional conditions of climate and soil through the process of natural selection. Current genetic differentiation among populations can be a result of the combined interaction of the following processes: adaptation to local growth conditions, adaptation to previous growth conditions, accidental events during the migrations, influx of genes from neighbouring populations, genetic drift, spontaneous mutations and directed selection by humans (Joly & Frascaria-Lacoste 2001, Heybroek 1992). Here, the term autochthonous is used to indicate woody plants that regenerated spontaneously or that were reproduced with local material, counting from the last ice age (Heybroek 1992). In comparison, the term native denotes that the growth site is a part of the natural geographic range of the species, and does not take the adaptation of a population to local ecological growth conditions into account. Trees and shrubs from native species that are obtained from provenances in different geological regions or climatic zones are not considered autochthonous. In this respect it is important to pay attention to the difference between provenance and seed source. Provenance is the original geographic area from which seeds were obtained. Seed source only refers to the area from which the seeds were harvested. Seeds collected in a stand in Meerdaal forest that was itself planted with trees coming from Spain, have as seed source Meerdaal forest, but the provenance is the location in Spain where the trees originate from.

1.2 Background: genetic diversity is a survival strategy

Mankind has high impact on the ecosystems in the world. We have the moral responsibility to take care of the world's biodiversity (Frankel & al. 1995) which is for the sake of our own survival in the long run. The Convention on Biological Diversity (Rio de Janeiro, 1992) stated that biodiversity should not only consider the diversity of species, communities and ecosystems. It directed to move downwards the ladder of biological hierarchy up to the genetic level. Here, it is stressed that genetic diversity is inherent to all living species, and is a necessary means of survival in dynamic ecological equilibria. It is the raw material of evolution. Specifically woody plants maintain the highest levels of intraspecific genetic variation of all life forms (Hamrick & al. 1992). The extent and the distribution of genetic variation within a species are of fundamental importance for its evolutionary potential and determine its chances of survival in the long run (e.g. Newton & al. 1999). This is the point where the guardianship of autochthonous genetic resources of woody plants is to be situated. Protecting the genetic variation of local populations through dynamic in situ and ex situ conservation strategies is the central aim of the presented project. Next to the Rio convention, that covers all living organisms, the EU ministerial conferences on the European

forests can be mentioned (Coart & al. 1998). Several resolutions explicitly emphasize the urgency of the preservation of local autochthonous genetic resources. Measures are being taken on a national scale (e.g. Teissier du Cros 2001). Especially for woody plants, being sessile and long-living organisms, genetic diversity is an indispensable prerequisite for securing evolutionary flexibility (Gregorius & Kleinschmit 1999, Newton & al. 1999). Some examples are given in Heybroek (1998) to demonstrate the importance of genetic diversity within a given tree species for its chances of survival. *Pseudotsuga menziesii*, a successful exotic species in many places of the world, is known for its high genetic diversity. A pine tree with similar economic potential, *Pinus resinosa*, shows much less genetic diversity, and is said to have been a disaster in plantation trials outside its natural growth area. Given the little knowledge on the genetic diversity of our autochthonous populations, caution and vigilance is highly recommended not to loose our autochthonous genetic heritage.

1.3 The issue: seeds of native species are dispersed by man over hundreds of kilometres

Many causes resulted in the shrinkage of the growth sites where autochthonous woody plants still survive in Flanders. Well known is the long lasting deforestation and intensive forest use that have started already during the early Middle Ages, the reforestation during the last century with species exclusively selected for wood production, as well as changes in land use (large scale expansion in agriculture, urbanisation, ...) (Tack & al. 1993). Less known but not less devastating is the provenance of forest reproductive material that is marketed nowadays in Flanders (Coart & al. 1998). For economic valuable tree species it is well known that the ecological growth conditions at the place where a provenance originates from, plays a substantial role in the chances of success of a plantation outside the region of origin (e.g. *Picea abies*, Danusevicius & Persson 1998; *Quercus robur* and *Q. petraea*, Svolba & Kleinschmit 2000; *Pseudotsuga menziesii*, Prat & Burczyk 1998). At the same time, provenances of economic less relevant woody species often have been neglected (Coart & al. 1998). Because of the cheap labour for seed harvest, many seed lots are imported from Southern and Eastern Europe. Plants grown from these seeds may be less adapted to regional growth conditions in Flanders. Some may flush and flower earlier in comparison to the autochthonous plants. Some may show morphological differences, and in the long run they may prove to be less vital. Although these differences have to be verified scientifically for the native species in Flanders, a nice example is described by Jones & al. (2001). They showed that autochthonous *Crataegus monogyna* in England is better adapted to the local growth sites. Autochthonous provenances were compared to several provenances originating from different places in Europe. Bud burst of the autochthonous provenance was later in comparison to all examined provenances, thorniness was higher, height and girth growth were lower and mildew infection was lower. Landscape designers in Flanders know that reconstruction of old hawthorn hedges is difficult to achieve with the commercially available fast-growing plant material. Large scale plantings of exotic provenances of indigenous woody species have become a threat for the remaining relicts of autochthonous populations as they spread foreign genes in the autochthonous populations through cross-pollination. Wagner (1999) demonstrates a clearly visible example of genetic introgression. Seedlings originating from one *Malus sylvestris* mother tree were cultivated. Fruits harvested from these pedigrees showed morphological variation ranging from pure small wild apples towards the large sizes of commercially cultivated apples. The mother tree was pollinated not only by wild apple trees but also by cultivated fruit trees from the neighbourhood.

1.4 Actions: a future for our genetic patrimony of woody plants

A few years ago actions were undertaken by the forestry administration of the Flemish Community, together with the Institute of Forestry and Game Management, towards the protection of the autochthonous woody plants in Flanders. Central aim is the preservation of the genetic diversity and the natural mechanisms responsible for the dynamic evolution of this diversity. As a

first step, a systematic inventory of growth sites harbouring autochthonous trees and shrubs has been started and is still going on. The growth sites of high value require an appropriate in situ conservation. If population sizes have not become too restrictive, measures should be taken to preserve and enhance natural conditions allowing a dynamic evolution through gene flow with neighbouring populations, stimulation of natural rejuvenation, replanting with locally harvested material, minimising cross-hybridisation with non-local provenances,... For example, a gene conservation program of *Populus nigra* in Flanders necessitates a reconstruction of the riparian ecosystem (Vanden Broeck & al. 2002). The ultimate goal of this project is to commercialise regional autochthonous plant material, substituting the necessity of import of foreign provenances. To this purpose, harvesting programs of autochthonous seeds on the original growth sites and the creation of autochthonous seed orchards are being organised. The whole process is supported by applied scientific research. Next to a general outlining of the different aspects of this project, outstanding findings of the inventory on the genera *Rosa*, *Crataegus* and *Quercus* are discussed.

2 Material and methods

2.1 Inventory of autochthonous woody plants

2.1.1 The method. The method of Maes (1993) to evaluate the autochthonous state of a tree or shrub is followed. First, present-day forests and wood banks are selected if they are indicated on the old Ferraris map of 1779 or on other historical topographic maps. Additional information on flora, soil condition and geomorphologic data further filter the potential interesting sites. In the field, trees and shrubs are evaluated according to a set of criteria. (a) The tree or shrub is a wild variety, no cultivate. For example, the leaves of wild apple trees (*Malus sylvestris*) are glabrous. Pubescence indicates influences of cultivated apples (Wagner 1999). The tree or shrub is old. Specifically large coppice stools can attain very old ages, counting several hundreds of years (e.g. Pigott 1989). The tree or shrub gives a spontaneous (not planted) impression. (b) The growth site is located within the natural geographic range of the species. The site conditions correspond with the ecological requirements of the species. The site is mentioned as afforested on historical topographic maps. (c) The tree or shrub is present on similar sites in the neighbourhood. (d) Several plants present in the tree, shrub or herb layer are indicators of ancient undisturbed woodlands (Tack & al. 1993).

Of course, not all criteria have to be met at the same time. They have to be assessed in relation to each other. Molecular genetic analyses can help the evaluation of the autochthonous nature of

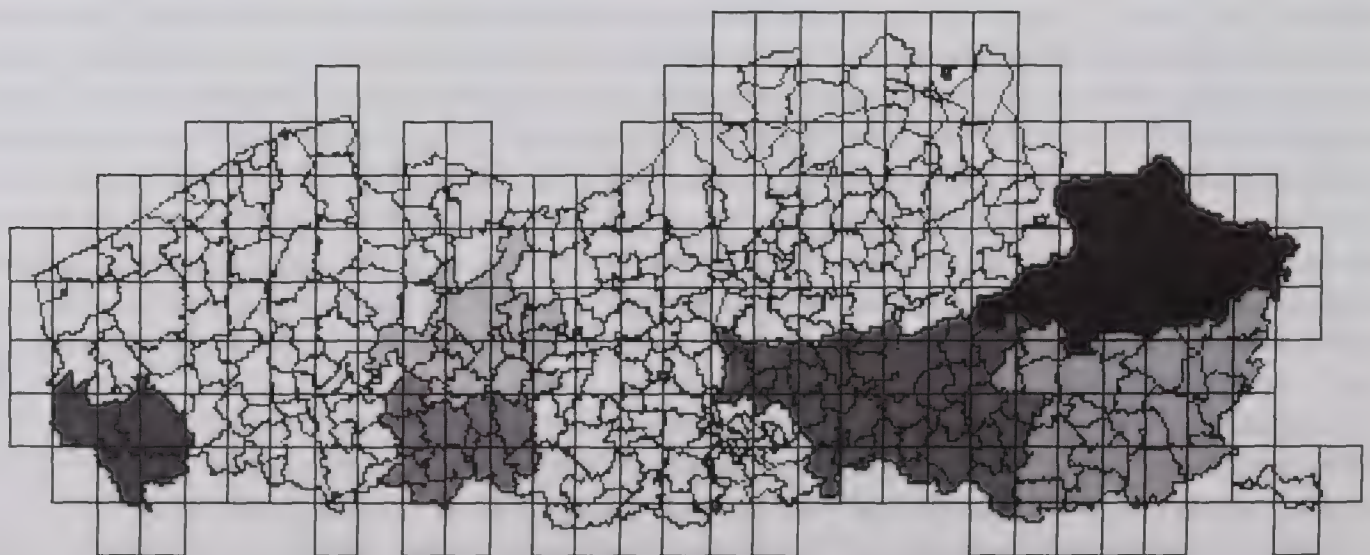


Figure 1. Up to date map of surveyed regions for autochthonous trees and shrubs in Flanders (for name of regions see text).

the woody plants. For example, chloroplast haplotype analysis of several autochthonous quoted stands of *Quercus robur* and *Q. petraea* in Flanders could refine the autochthonous evaluation and at the same time localise the stands in the European re-colonisation routes since the last ice age (Anonymous 2001b, Dumolin-Lapègue & al. 1997, Ferris & al. 1998).

2.1.2 Up to date surveyed area. Since 1997, inventories of autochthonous woody plants has been carried out in Flanders by specialised botanists, on the authority of the Flemish Community (Maes & Rövekamp 1998, Rövekamp & Maes 1999, Maes & Rövekamp 2000, Rövekamp & Maes 2000, Rövekamp & al. 2000, Opstaele 2001). Regions already surveyed for autochthonous growth sites are the south-west of West-Vlaanderen, the 'Vlaamse Ardennen', the 'Vlaamse vallei' surrounding Gent, forest districts of Leuven, Hasselt, Hechtel and Bree (fig. 1). Within the coming years the whole of Flanders will be surveyed.

3 Results and discussion

3.1 In situ and ex situ conservation strategies

Autochthonous genetic resources can be protected in several ways. (a) Appropriate regulations are essential. Existing relevant regulations comprise the recent management guidelines of the Flemish forestry administration (Anonymous 2001a). It states that autochthonous growth sites within the boundaries of domain forests should be protected and in addition should be properly managed with regard to the reproduction of this material. Next to this, growth sites within areas of special interest in terms of nature conservation (e.g. Natura 2000 network) have decent chances of proper conservation, as rules on land use are restrictive. Special focus is recommended for the sites outside public forests and apart from areas with special concern from nature conservation. These are the most vulnerable to damage and destruction. They require more consideration from local administrators in charge of control and permit granting. (b) Both governmental and non-governmental organisations purchase growth sites. Persuasion for purchase of the most valuable sites is recommended. (c) Professional management of sites harbouring autochthonous woody plants is at the moment often neglected and has to be encouraged at the different levels of stake holders. It can increase the chances of survival and expansion of the local populations. Natural rejuvenation is a prerequisite in a dynamic in situ conservation program (Teissier du Cros 2001). For example, several rare shrubs require high amounts of light for flowering and seed set. Also, a buffering zone may reduce the inflow of fertiliser and other antropogenic influences... (d) Static ex situ conservation by collecting plants in open-air plantations is mandatory for locally or regionally endangered autochthonous relic populations, for which the population size has become too small, the risk of destruction being too high or a serious threat being imposed by disease. The disappearance of individuals has higher impact on the genetic diversity of small and reduced populations in comparison to larger ones (Lefèvre 2001a, Hedrick 2001). Therefore, the principal purpose is to preserve the remaining genetic diversity. To exclude possible pollination from allochthonous sources the mother plants are vegetatively propagated. For several years, basic material of several species has been collected in the Institute of Forestry and Game Management. The list of species will augment in the future. (e) The whole process will only be successful if all stakeholders support it. Information channelling is therefore considered as a main part of actions taken within the above delineated framework.

3.2 Autochthonous forest reproductive material

Planting of populations that have been grown from seeds taken from distant trees but which still belong to the same bio-region can be considered as a dynamic ex situ conservation strategy. It can be compared to the classical breeding programs in which plus-trees from different places within

one bio-region are brought together in seed orchards (Lefèvre 2001b). This ex situ conservation strategy is applicable to the situation in Flanders, where the landscape is highly fragmented. Surveyed growth sites of autochthonous woody plants are often small areas where only limited numbers of trees and shrubs grow.

3.2.1 Provenance areas. Autochthonous forest reproductive material is obligatory linked to a bio-region, a provenance area in which the ecological growth conditions are uniform. As a general rule, autochthonous seeds harvested at different places within a provenance area are mixed. But, the plants grown from these seeds can only be planted within the same provenance area. Furthermore, delineation of provenance areas is needed, as seed orchards will be realized for every area (see 3.2.3). At the moment, Flanders is divided into several autochthonous provenance areas, taking several arguments into account. (a) According to the definition of autochthonous woody plants, provenance areas are characterized by uniform ecological growth conditions. The phytogeographical regions of the flora of Lambinon & al. (1998) form the basis. (b) The principle of vigilance states that the provenance areas should be small enough so as not to mix populations that are genetically differentiated. (c) At the other end, too small provenance areas may harbour too small populations with insufficient genetic diversity to guarantee evolutionary flexibility (Gregorius & Kleinschmit 1999, Hedrick 2001). (d) Defining small provenance areas enlarges the amount of small seed lots for the cultivation of autochthonous reproductive material, which makes the practice of tree nursery very complex and augments the chances on practical mistakes. Considering these arguments, Flanders is momentarily divided into six provenance areas: the coast, sandy Flanders, Brabant district west, Brabant district east, the Campine and the Meuse valley. Since the inventory of autochthonous growth sites still goes on and genetic analyses are carried out on several species, new aspects on autochthonous populations may require adjustment of the defined areas.

3.2.2 In situ harvest. Since 1998 autochthonous seeds have been harvested on surveyed locations in Flanders, with the help of several governmental and non-governmental administrations and organisations. Species are focussed on that are often used in planting actions of all kinds. Naturally rare species should not be planted in large quantities and therefore not have been collected, or in small amounts. Seeds are obtained from at least 30 mother plants per species within one provenance area. As the autochthonous growth sites are very fragmented and small, this implies a time-consuming harvest, visiting many different places within the provenance area. This practice guarantees a broad genetic diversity in the plant material that will be cultivated from the obtained seed (Heybroeck 1992). For the cultivation of the autochthonous plants two ways are attempted. One part is grown in the two governmental nurseries of the Flemish forest department located in Koekelare and in Brasschaat; the other part is raised in private nurseries under a sales-contract.

3.2.3 Seed orchards. The aim of autochthonous seed orchards is double. They should produce large amounts of vital seed crop and at the same time preserve the gene pool of the autochthonous populations from which the seed-bearing plants originate. The basic material for seed orchards has been being collected since 1999 on the Institute of Forestry and Game Management. To this purpose, the best quoted autochthonous trees and shrubs in the inventories have been vegetatively propagated. In this process, a selection of vitality and of economic value, if applicable, of the propagated plants is possible. A minimum of 30 mother plants per species is required for every seed orchard. At the moment basic material is collected for native species that are currently used in all types of plantations in the Flemish countryside and forests. The seed orchards will mainly be planted on locations belonging to the Flemish forestry administration.

3.2.4 Certification. European legislation (EU directive 1999/105/EG) necessitates the adaptation of national legislation (article 42 of the Flemish forest decree) on the marketing of forest reproductive material by the beginning of 2003. The possibility will be included to certify autochthonous reproductive material, also for species with no economic value.

3.3 Outstanding findings from the inventory

(Maes & Rövekamp 1998, Rövekamp & Maes 1999, Maes & Rövekamp 2000, Rövekamp & Maes 2000, Rövekamp & al. 2000, Opstaele 2001)

3.3.1 Rare members of the *Rosaceae* family: *Rosa* spp. For the identification Henker & Schulze (1993) was followed. The inventory includes valuable information on the distribution of autochthonous botanical roses in Flanders. Table 1 displays an up to date list of surveyed taxa. A herbarium and a living collection are being build up at the Institute of Forestry and Game Management (tab. 2).

Table 1. Taxa of autochthonous roses in Flanders that were surveyed to date.

	1	<i>R. arvensis</i> HUDS.
	2	<i>R. stylosa</i> DESV.
	3	<i>R. pimpinellifolia</i> L.
Dogroses	4	<i>R. canina</i> L.
	4.1	<i>R. canina</i> var. <i>canina</i> L.
	4.2	<i>R. canina</i> var. <i>dumalis</i> BAKER
	4.3	<i>R. canina</i> var. <i>scabrata</i> CRÉPIN apud SCHEUTZ
	4.4	<i>R. canina</i> var. <i>andegavensis</i> (BASTARD) DESPORTES
	4.5	<i>R. canina</i> var. <i>blondaeana</i> (RIPART) CRÉPIN
	5	<i>R. subcanina</i> (CHRIST) DALLA TORRE & SARNTH.
	6	<i>R. corymbifera</i> BORKH.
	6.1	<i>R. corymbifera</i> var. <i>corymbifera</i> BORKH.
	6.2	<i>R. corymbifera</i> var. <i>deseglisei</i> (BOREAU) CHRIST
	7	<i>R. caesia</i> SM. in SOWERBY
	8	<i>R. tomentella</i> LÉMAN
Downy roses	9	<i>R. tomentosa</i> SMITH
	10	<i>R. pseudoscabriuscula</i> (R. KELLER) H. HENKER & G. SCHULZE
Sweet briars	11	<i>R. agrestis</i> subsp. <i>agrestis</i> SAVI
	12	<i>R. micrantha</i> BORRER ex SM. in SOWERBY.
	13	<i>R. columnifera</i> SCHWERTSCHL.
	14	<i>R. rubiginosa</i> L.
Hybrids	15	<i>R. x irregularis</i> DESEGL. & GUILLON (<i>R. canina</i> x <i>R. arvensis</i>)
	16	<i>R. x nitidula</i> BESSER. (<i>R. canina</i> x <i>R. rubiginosa</i>)
	17	<i>R. stylosa</i> x <i>R. canina</i>

One of the rarest species is *Rosa stylosa*. Several individuals were identified in the south-west of West-Vlaanderen. This rose is characterized by a hip with a strong conical disc, from which a bundle of styles emerges (fig. 2). Another remarkable rose is *Rosa caesia*. In the coastal dunes at the Westkust a few individuals survive. This rose shows a typical hip with a wide orifice and erect sepals (fig. 3). Other rare roses were found back at several places in Flanders. For example, the sweet briar *Rosa micrantha* is present, although in very low number, both in the south of Limburg and in the south-west of West-Vlaanderen. A very small population of another sweet briar *Rosa agrestis* grows in the south of Limburg. The shape of the leaflets can distinguish both sweet briars. The downy rose, *Rosa pseudoscabriuscula* is distributed along the south of Flanders, but always in very low number. The very rare dogrose varieties *R. canina* var. *andegavensis* and *R. corymbifera*

var. *deseglisei* can be found in the southwest of West-Vlaanderen. Both are characterized by glands on the pedicel and on the hip.

Table 2. Herbarium and living collection of autochthonous roses (A) and autochthonous hawthorns (B) at the Institute of Forestry and Game Management.

The numbers refer to the individuals from which material was collected. The number of seeds, seedlings and cuttings obtained per individual mother plant may vary and is not indicated. Reference material from outside Flanders is included.

Species		Herbarium	Seedling	Cutting
Roses	<i>Rosa arvensis</i>	11	4	6
	<i>R. x irregularis</i>	4	1	4
	<i>R. stylosa</i>	6	3	2
	<i>R. pimpinellifolia</i>	5	1	
	<i>R. canina</i> var. <i>canina</i>	17	6	9
	<i>R. canina</i> var. <i>dumalis</i>	23	10	5
	<i>R. canina</i> var. <i>scabrata/blondaeana</i>	2		
	<i>R. canina</i> var. <i>andegavensis</i>	11	5	3
	<i>R. canina</i> var. <i>blondaeana</i>	1	1	
	<i>R. subcanina</i>	3	1	1
	<i>R. dumalis</i>	2	1	
	<i>R. corymbifera</i> var. <i>corymbifera</i>	24	19	9
	<i>R. corymbifera</i> var. <i>deseglisei</i>	8	3	4
	<i>R. subcollina</i>			
	<i>R. caesia</i>	6	2	
	<i>R. tomentella</i>	45	14	17
	<i>R. tomentosa</i>	2	2	2
	<i>R. pseudoscabriuscula</i>	21	8	6
	<i>R. sherardii</i>	1	1	
	<i>R. villosa</i>	2		
	<i>R. agrestis</i>	10	3	7
	<i>R. agrestis</i> x <i>R. canina</i>	1		
	<i>R. inodora</i>		1	
	<i>R. elliptica</i>	1	1	
	<i>R. micrantha</i>	8	3	4
	<i>R. columnifera</i>	5	4	4
	<i>R. rubiginosa</i> var. <i>umbellata</i>	12	5	
	<i>R. majalis</i>	1		
	<i>R. vosagiaca</i>	1	1	1

Species		Herbarium	Seed
Hawthornst	<i>Crataegus monogyna</i>	21	21
	<i>C. laevigata</i>	10	10
	<i>C. x media</i>	9	9
	<i>C. x subsphaericea</i>	12	12
	<i>C. x macrocarpa</i>	6	6

3.3.2 Rare members of the Rosaceae family: *Crataegus* spp. For the identification Christensen (1992) was followed. Apart from the well-known species *Crataegus monogyna* Jacq. and *C. laevigata* (Poiret) DC., the distribution of the uncommon hybrids of these two species and *C. rhipidophylla* Gandoger was not properly documented before the inventory. *C. x subsphaericea* Gandoger is the rare hybrid between *C. monogyna* and *C. rhipidophylla*. It grows all along the Brabant district (Lambinon & al. 1998). It is characterized by long acuminate sepals, serrate

stipules of the inflorescence and leaf margins that are more serrate in comparison to *C. monogyna* (fig. 4). Even rarer is *C. x macrocarpa* Hegetschw., the hybrid between *C. laevigata* and *C. rhipidophylla*. Typical are the long acuminate sepals, relatively big fruits, sharp serrate leaf margins and a deeper incision in the leaves in comparison to *C. laevigata*. Two small populations are found in the south-west of West-Vlaanderen and in the south of Limburg. A herbarium and a living collection of the autochthonous *Crataegus* taxa are being build up at the Institute of Forestry and Game Management (tab. 2).

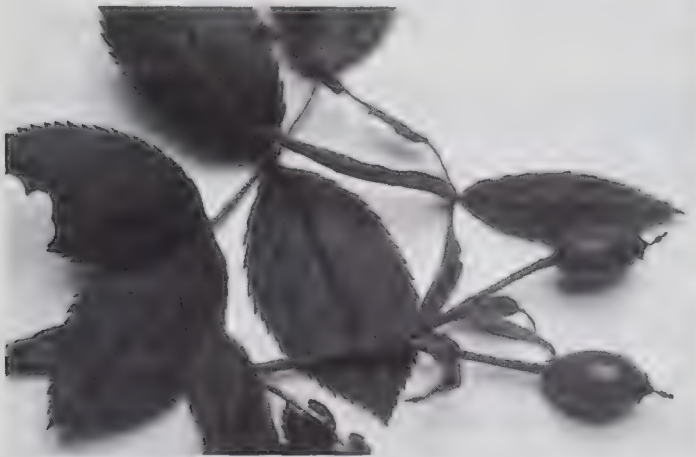


Figure 2. A few individuals of *Rosa stylosa* grow in the south of West-Vlaanderen. The rose is characterised by a hip with strong conical disc, from which a bundle of styles emerges.



Figure 3. A few individuals of *Rosa caesia* survive in the coastal dunes at the Westkust. Typical for this rose is a wide orifice of the hip and erect sepals.



Figure 4. *Crataegus x subsphaericea* is characterised by long acuminate sepals and serrate stipules at the inflorescence.



Figure 5. Old coppice stool of *Quercus petraea* growing on poor sandy soil in Limburg, with a circumference at ground level of 24 m. The individual stems all belong to one and the same individual

3.3.3 Old coppice stools of oak. Analysis of the chloroplast DNA in young leaves of oak trees, together with pollen analyses, resulted on a European scale in the reconstruction of the migration routes of oaks since the last ice age from their refugia along the Mediterranean see towards the north (Petit & al. 1993, Dumolin-Lapègue & al. 1997). It was shown that two main migration routes, from the Iberian Peninsula and from Italy, come together in Flanders (Anonymous 2001b). To this purpose, several stands with old coppice wood of oak were analysed, including both native species *Quercus robur* L. and *Q. petraea* Liebl. The largest coppice stools of both species grow on the poor and dry sandy soils of the Campine in the province of Limburg and measure up to 24 m circumference at ground level (fig. 5). Autochthonous *Q. petraea* and *Q. robur* of the Italian

migration line grow in Limburg, which may be the east border of the distribution area of this line. Descendants of the Spanish line can be found everywhere in Flanders.

Grafts of the largest oak stools will be preserved in gene banks at the Institute of Forestry and Game Management.

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Abstracts of other contributions to ecology and conservation

Impact of climate change on the vegetation of a Belgian rich fen: a microcosm study

Véronique Van Haesebroeck¹, Dirk Boeye² & Patrick Meire¹

¹ University of Antwerp, Department of Biology, Research Group of Ecosystem Management,
Universiteitsplein 1, B-2610 Wilrijk, Belgium
vero@uia.ua.ac.bepmeire@uia.ua.ac.be

² Institute of Nature Conservation, Kliniekstraat 25, 1070 Brussels, Belgium
dboeye@be.packardbell.org

Characterised by a low productive, evergreen vegetation, rich fens are amongst the most species rich herbaceous vegetation types of Western Europe. Their limited size and distribution result in their importance as a refuge for threatened species and their importance for nature conservation. The low productivity of the rich fen vegetation is induced by low soil fertility (especially P) and by the base status of the soil. Indications for changes in the soil chemistry (acidification, increased P- availability) of these groundwater depending ecosystems due to varying hydrological conditions and their effects on the vegetation, formed the basis of this Global Change study.

To investigate the differential effects of drought, acidification and concomitant nutrient availability changes on the low growing rich fen vegetation, a microcosm experiment was initiated, in which intact sods were subjected to artificial drought. Soil solution sampling took regularly place, changes in growth and distribution of different plant species were followed, and small vegetation fractions were harvested to determine the plant nutrient content. Soil and total above- and belowground biomass were analysed in detail at the end of the experiment.

The results indicate that acidification of the soil environment occurred immediately upon drought, causing changes in solubility of Ca and Mg (increased) and of Fe and Mn (decreased). Considering the vegetation distribution and density, acid tolerant species (*Molinia caerulea*) had expanded their growth, while acid intolerant species (*Eleocharis quinqueflora*) became much less abundant after two growing seasons. Also changes in plant height and nutrient content were detected at the end of the experiment. The results of this climate change study will be used to create a model which will make possible correct estimation of management effects in rich fens.

Richesse spécifique, rareté spécifique et coefficients d'Ellenberg (N,F,L) dans un réseau de sites protégés de Fagne-Famenne et de la Lorraine belge

Jean-Paul Herremans & Martin Tanghe

Université Libre de Bruxelles, Department of Botany, Laboratoire de Botanique systématique et de Phytosociologie,
Avenue F.D. Roosevelt 50, Campus du Solbosch, B-1050 Bruxelles, Belgium; mtanghe@ulb.ac.be

Dans un set de 219 relevés phytosociologiques au sein de communautés prairiales du Molinion ou associées, les coefficients moyens d'azote (N), de lumière (L) et d'humidité (F) d'Ellenberg ont été calculés ainsi que la richesse spécifique et un coefficient moyen de rareté spécifique.

Certains de ces coefficients montrent des corrélations statistiquement significatives: rareté spécifique et lumière, rareté spécifique et humidité et richesse spécifique et azote. Ces corrélations sont discutées.

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Des coefficients moyens ont également été calculés pour des unités de végétation identifiées par le programme DECORANA. Une corrélation significative est mise en évidence entre la richesse spécifique moyenne et le coefficient N moyen de ces unités.

Diversité des diatomées benthiques et qualité de l'eau des ruisseaux au Luxembourg

Luc Ector¹, Frédéric Rimet¹, Loïc Tudesque¹ & Lucien Hoffmann^{1,2}

¹ Centre de Recherche Public - Gabriel Lippmann, Cellule de Recherche en Environnement et Biotechnologies, 162a, avenue de la Faïencerie, L-1511 Luxembourg; ector@crpgl.lu

² Université de Liège, Institut de Botanique, Sart Tilman B.22, B-4000 Liège, Belgium

Cette étude concerne la partie rhithrale des cours d'eau du Luxembourg. Un inventaire de la flore diatomique des ruisseaux du Luxembourg a permis d'évaluer leur qualité biologique et également d'identifier des communautés caractéristiques des grandes régions géologiques.

Les diatomées benthiques ont été récoltées par brossage de pierres ou de galets en faciès lotique afin d'éviter les effets de dérive et de dépôt d'algues mortes non fixées. Au laboratoire les algues ont été débarrassées de leur contenu cellulaire par attaque à l'eau oxygénée (H₂O₂ 130 vol) et les carbonates de calcium ont été éliminés par addition d'acide chlorhydrique par une attaque acide (HCl). Les frustules siliceux des diatomées ont été montés dans une résine à fort pouvoir de réfraction (Naphrax). Les comptages ont été effectués au microscope photonique (grossissement 1000X) et portent au minimum sur 400 individus. Les mesures physico-chimiques ont été réalisées simultanément aux échantillonnages de diatomées. Au total, les diatomées de 289 échantillons de périphyton ont été analysées sur deux saisons (printemps et automne entre 1994 et 1997). La liste taxonomique des diatomées épilithiques des ruisseaux totalise plus de 400 taxons dont environ 25% sont des citations nouvelles pour le Grand-Duché de Luxembourg.

Une analyse hiérarchique effectuée sur les mesures physico-chimiques a permis de séparer deux principaux groupes de stations. Ces deux groupes correspondent aux deux écorégions du Luxembourg : la région schisteuse de l'Oesling au nord et la région gréseuse du Gutland au sud. A partir des comptages de la microflore algale, une analyse TWINSPLAN a été réalisée et a permis de séparer sur base des 100 espèces principales de diatomées deux groupes de stations localisés l'un dans l'Oesling l'autre dans le Gutland. La géologie semble donc être un des facteurs principaux responsable de la structure des peuplements diatomiques dans les ruisseaux du Luxembourg. Les paramètres chimiques qui permettent le plus de séparer les ruisseaux de ces deux régions sont le pH, la dureté carbonatée, la dureté totale et la conductivité (moyenne pour l'Oesling: pH = 7,3 ; dureté carbonatée = 3,9 °F ; dureté totale = 70,6 °F ; conductivité = 205,5 µS/cm ; moyenne pour le Gutland: pH = 7,9 ; dureté carbonatée = 24,1 °F ; dureté totale = 366,3 °F ; conductivité = 764,4 µS/cm). L'analyse a également permis de définir deux sous-groupes de stations séparant les diatomées oligosaprobies et les taxons polysaprobies à l'intérieur de chacune des deux écorégions. La pollution est le facteur qui différencie ces sous-groupes. Les espèces les plus indicatrices des 4 sous-groupes ont été déterminées par la méthode de l'Indicator Species Analysis. Dans l'Oesling, les diatomées neutrophiles oligosaprobies les plus caractéristiques du rhithron sont *Achnantheidium minutissimum*, *A. subatomus*, *Diatoma mesodon*, *Gomphonema olivaceum* var. *olivaceoides* et *Psammothidium daonense*. Les espèces neutrophiles indicatrices des ruisseaux pollués de l'Oesling sont *Fistulifera saprophila*, *Gomphonema parvulum* et *Nitzschia palea*. Dans le Gutland, seuls quelques rares ruisseaux de référence ont pu être trouvés avec comme taxons indicateurs alcaliphiles *Achnantheidium biasolettianum*, *Amphora pediculus*, *Cocconeis placentula* var. *lineata*, *Gomphonema olivaceum* var. *olivaceum* et *G. pumilum*. La majorité des petits cours d'eau du Gutland sont contaminés, les espèces polysaprobies les plus représentatives sont *Eolimna subminuscula*, *Mayamaea atomus* var. *permitis*, *Navicula gregaria* et *Planothidium frequentissimum*.

D'autre part, ces analyses floristiques ont permis de dresser des cartes de qualité hydrobiologique des cours d'eau luxembourgeois au moyen d'indices basés sur les peuplements de diatomées benthiques. L'Indice de Polluo-sensibilité Spécifique (IPS) a été choisi comme indice de référence car il est utilisé en routine dans différents pays limitrophes pour surveiller la qualité des cours d'eau. L'évaluation de la qualité biologique des ruisseaux du Luxembourg par les diatomées (IPS) est en concordance avec l'estimation de la qualité chimique au moyen de paramètres physico-chimiques classiques (Indice de Pollution Organique: IPO). L'analyse des communautés de diatomées benthiques constitue donc un outil précieux qui estime de manière fiable la qualité hydrobiologique des cours d'eau du Luxembourg mais permet également de reconnaître les écorégions naturelles d'après leur microflore.

Vlavedat: aanzet tot natuurtypen en plantengemeenschappen in Vlaanderen

Veerle Vandenbussche², Filiep T'jollyn² & Maurice Hoffmann^{1,2}

¹ Universiteit Gent, Vakgroep Biologie, Onderzoeksgroep Terrestrische plantenecologie en Vegetatiekunde
K. L. Ledeganckstraat 35, B-9000 Gent, Belgium

² Instituut voor Natuurbehoud, Kliniekstraat 25, Brussel, Belgium
veerle.vandenbussche@instnat.be

Vlavedat staat voor VLAamse VEgetatieDATabank. Deze databank werd opgebouwd in het kader van het project "Opmaak van een systematiek van natuurtypen voor de biotopen duin, slik en schor, moeras, heide en grasland" in opdracht van het Ministerie van de Vlaamse Gemeenschap, Afdeling Natuur, en bevat momenteel ca. 25000 vegetatieopnamen uit Vlaanderen. Van deze opnamen werden de biotische gegevens en – indien beschikbaar – relevante abiotische gegevens ingevoerd. De analyse van de databank laat toe relaties te leggen tussen natuurtypen enerzijds en hun geografische ligging, soortenrijkdom, en omgevingsfactoren anderzijds. Als basis voor het afbakenen van natuurtypen werd gekozen voor de plantengemeenschap, omwille van haar visuele herkenbaarheid en omdat ze kan beschouwd worden als basiseenheid van de habitat en het natuurlijk milieu. De natuurtypen worden zoveel mogelijk afgebakend op het syntaxonomisch verbondsniveau, omwille van de herkenbaarheid in het veld, het ecologisch kunnen onderbouwen en met het oog op het beperken van het aantal natuurtypen. De selectie van de te bestuderen verbonden is volledig gebaseerd op "De Vegetatie van Nederland" (Schaminée et al. 1995, 1996, 1998). De kensoorten voor Nederland werden getest op hun relevantie voor deze verbonden in Vlaanderen.

De ruwe opnamensets werden geanalyseerd met een classificatieprogramma (TWINSPAN, Hill 1979) en met een syntaxonomisch identificatieprogramma (ASSOCIA, van Tongeren 2000). Er werd een link gelegd tussen de relationele databank in Access en een GIS (Arcview), waardoor de verspreiding van de natuurtypen gevisualiseerd kan worden.

Uit de analyses blijkt dat een aantal natuurtypen (verbonden) zeer zeldzaam zijn in Vlaanderen of zeer zwak vertegenwoordigd in de databank. Vooral de zeldzaamheid van vele kensoorten of de geringe presentie ervan in de databank zorgen voor interpretatiemoeilijkheden bij de afbakening van de verbonden. Er zijn nog een aantal inhoudelijke en geografische hiaten in de data, en vooral het gebrek aan informatie over (gemeten) abiotiek is een knelpunt. Veel verder onderzoek en gegevens zijn nodig om een syntaxonomie van de plantengemeenschappen in Vlaanderen te kunnen opstellen. Uitgebreid biotisch en abiotisch veldonderzoek zijn hiervoor zeer wenselijk.

Vlavedat zou in de toekomst, op z'n minst gedeeltelijk en rekening houdend met de specifieke voorwaarden gesteld door de leveranciers van origineel, ongepubliceerd opnamemateriaal, publiek raadpleegbaar moeten zijn. Vlavedat is fysisch ondergebracht in het Instituut voor Natuurbehoud te Brussel.

Een gedifferentieerde checklist van de Bryophyta van Vlaanderen als aanloop naar een Rode Lijst

Gert De Smedt

Nationale Plantentuin van België, Domein van Bouchout, B-1860 Meise, Belgium
Gert.Desmedt@br.fgov.be

Van Belgische Bryophyta bestaat nog steeds geen Rode Lijst. De reden hiervoor is het ontbreken van een bruikbare dataset, waardoor het toepassen van de IUCN criteria wordt uitgesloten.

In samenwerking met het Instituut voor Natuurbehoud stellen we een gedifferentieerde specimen-gebaseerde checklist op van de hauw-, lever- en bladmossen van Vlaanderen. Vlaanderen wordt hiervoor in 5 ecoregio's opgedeeld: Duinen, Polders, Zand- en Zandleemstreek, Kempen en Leemstreek. Voor elke regio wordt de aanwezigheid van een soort nagegaan over de volgende vier periodes: voor 1900, 1901-1950, 1951-1980, 1981-2000.

De database zal een aanduiding geven naar soortenrijkdom en uitsterven van soorten in Vlaanderen en kan aldus als basis dienen voor het opstellen van een Rode Lijst.

Diatoms and macrophytes as ecological indicators in rivers

Ludwig Triest

Algemene Plantkunde en Natuurbeheer, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussel, Belgium
ltriest@vub.ac.be

Biological indicators of degradation as well as improvement of aquatic habitats, especially macrophyte and diatom species are monitored to assess also the ecological quality of running waters. Conceptual improvement of bio-indicator systems and the development of reference images will lead to a better understanding of the species dynamics in changing environments. The investigation of diatom assemblages attached to herbarium specimens from earlier centuries might deliver information about reference images. An analysis on *Scirpus* herbaria showed that the saprobity (on the basis of diatoms) of the river Schelde has not changed significantly during 150 years. Diatom assemblages on historical herbarium specimens of submerged *Potamogeton* species however indicated significant low saprobity and good ecological quality of many rivers in Flanders except for the rivers Leie and Zenne. Case-studies are also made on diatom communities from natural substrates and on the colonization of diatoms on artificial substrates for monitoring purposes in function of time and of water quality in Belgian rivers (Schelde, Rupel, Zenne, Nete, Woluwe, brackishwater creeks) and African rivers (Sondou Miriu, Kasat and Nyando in the watersheds of Lake Victoria, Nairobi river). Macrophyte monitoring in rivers and in seepage zones is related to chemical environmental parameters of the water or substrate and to spatial and physical habitat characteristics.

De eerste regionale bosinventarisatie van het Vlaamse Gewest (1997-1999)

Bart Roelandt

Ministerie van de Vlaamse Gemeenschap, Afdeling Bos & Groen, Graaf de Ferraris gebouw,
Koning Albert II-laan, 20 bus 8, B-1000 Brussel, Belgium; Bart.Roelandt@lin.vlaanderen.be

De bosinventarisatie heeft als doel recent en betrouwbaar dendrologische en fyto-sociologische cijfermateriaal te leveren betreffende het bos in Vlaanderen. Daartoe werd een steekproef van het Vlaamse bos opgezet.

Voor het vegetatiekundig deel werden de helft van de voor bosbouwmetingen geselecteerde proefvlakken bemonsterd in een 1km x 1km meetnet. Het meetnet werd uitgezet op de boskartering, een digitale kaart van het Vlaamse bos. Van deze 1564 proefvlakken werden er 1281 opgemeten (81%). De Braun-Blanquet methode voor het maken van fyto-sociologische opnamen werd gevolgd.

Deze opnamen werden gebruikt om een bostypologie van het Vlaamse bos op te stellen uitgaande van de floristische samenstelling van de proefvlakken. Om enkele zeldzame bostypen te kunnen beschrijven werden extra, gerichte bemonsteringen uitgevoerd en vegetatieopnamen uit andere databanken gebruikt. Zo werden 41 opnamen buiten het vegetatienetwerk in de classificatie en de beschrijving van de bostypen betrokken. Het vernieuwende aan, en daardoor de kracht van deze bostypologie is dat ze gebaseerd is op een realistische en objectieve staalname van het Vlaamse bos.

De classificatie gebeurde met behulp van Twinspan, databankbeheer m.b.v. Ms-Access en Turboveg en tabellarische bewerkingen m.b.v. Megatab.

32 bostypen werden onderscheiden. Van elk bostype is een beschrijving gemaakt. De beschrijving van de bostypen omvat steeds een aantal rubrieken:

- het aandeel van het bostype in het totale bosareaal van Vlaanderen;
- het huidige en potentiële areaal, de verdeling over de eigenaarcategorieën;
- het relatief aandeel (de verhouding van het actuele areaal op het potentiële areaal) en relatieve zeldzaamheidsklasse (verhouding relatief aandeel t.o.v. het actuele areaal);
- het voorkomen van elk bostype in de fyto geografische districten met behulp van een verspreidingskaart;
- de standplaats en preferente bodemkarakteristieken afgeleid uit een overlay met de digitale bodemkaart;
- de floristische samenstelling met weglating van de soorten met een presentie lager dan 10%, een minimumareaalkurve;
- differentiërende soorten t.o.v. verwante bostypen, ecologische spectra op basis van de Ellenberggetallen;
- een ecogram op basis van de Ellenberggetallen voor zuurgraad en vochtvoorziening;
- de fyto sociologische verwantschap toegelicht met behulp van de determineersleutel van S. van der Werf;
- enkele ouderdomskarakteristieken en bodemgebruikshistoriek afgeleid uit een overlay met historische kaarten.

Negentien bostypen konden worden herkend als verzadigde bosgemeenschappen. Twaalf bostypen kunnen slechts als onverzadigde gemeenschap benoemd worden. Eén bostype, het "duinbos" werd slechts beschreven als een complex van verschillende bosgemeenschappen.

Bijna alle bekende bostypen uit Vlaanderen zijn opgenomen in deze bostypologie. Slechts enkele zeer zeldzame bostypen, die in Vlaanderen zeer fragmentair ontwikkeld zijn, zoals het Veldbies-Beukenbos, het Parelgras-Beukenbos, het kalk-Beukenbos, het Berkenbroek en het oligotrofe Elzenbroek, zijn niet opgenomen in deze studie.

Plant community assembly along dendritic networks of small forest streams

Olivier Honnay, Wim Verhaeghe & Martin Hermy

K.U.Leuven, Laboratorium voor Bos, Natuur & Landschap, Vital Decosterstraat 102, B-3000 Leuven, Belgium
olivier.honnay@agr.kuleuven.ac.be

Although insight into factors (local and regional) that structure communities is growing, the specific contribution of each of these factors generally remains unknown. Moreover, the extent to which community assembly is intrinsically indeterministic (i.e., the degree to which community composition depends on chance events) remains an open question. The complexity of this issue requires field studies in a semi-controlled environment. We studied species richness and community composition of a guild of phreatophytes along dendritic networks of small forest streams in Western Belgium. The streams, situated at the forest-covered headwaters of six different watersheds and characterized by homogeneous environmental conditions, impose spatial

dispersal constraints to the plant species. This allowed us to assess the relative importance of deterministic processes guiding community assembly. More specifically, we focused on the role of species migration and colonization processes relative to local processes (competitive exclusion and passive habitat selection) on species richness and on community composition. Our analyses at three consecutive levels (species number, community composition, and species) revealed that plant community assembly along the stream systems is based on 1) historical and stochastic colonization events of species and 2) subsequent deterministic downstream dispersal processes. Apparently, (due to the influence of historical chance events) deterministic processes are not necessary resulting in community convergence. In addition we show that continuous downstream dispersal and colonisation can compensate for local extinction processes. This is another piece of evidence that, when studying community composition, it is absolutely necessary to place communities in their spatial context.

Elaboration de la Liste Rouge de la flore wallonne (Ptéridophytes et Spermatophytes)

Jacqueline Saintenoy-Simon

Présidente de l'Amicale Européenne de Floristique, rue Arthur Roland 61 B, B-1030 Bruxelles, Belgium

En 1969, Lawalrée et Delvosalle publiaient 'Ptéridophytes et Spermatophytes rares, disparus ou menacés de disparition en Belgique'. Dans cet ouvrage, plus de 350 espèces de plantes de Wallonie étaient mentionnées. Il s'agissait d'une 'Liste Rouge' avant la lettre. Depuis lors, plus aucun bilan complet de la 'santé' de la flore de Wallonie n'avait été dressé. Il s'avérait donc absolument nécessaire de mettre au point une Liste Rouge actualisée de la flore de Wallonie (Ptéridophytes et Spermatophytes).

Méthode de travail. Le travail destiné à l'élaboration de la Liste Rouge a consisté à réaliser, pour chaque taxon retenu, une vaste synthèse des données disponibles de manière à comparer les données anciennes et récentes.

Les données anciennes proviennent: du Prodrôme de la flore belge (Durant 1899); de la Flore générale de Belgique (Lawalrée 1950 à 1966, Fabri 1993); de l'Atlas de la flore belge et luxembourgeoise (van Rompaey et Delvosalle 1979), pris comme référence; etc.

Les données récentes ont été puisées: dans la bibliographie (plusieurs centaines d'articles, publiés de 1980 à 2001, ont été dépouillés, dont de nombreux compléments à l'Atlas); dans les listes floristiques de l'A.E.F. dont une partie est maintenant informatisée; dans divers documents non publiés.

Pour chaque taxon une fiche (largement inspirée de celle qui est utilisée dans le Livre Rouge de la Flore menacée de France) (Olivier, Galland, Maurin 1995), accompagnée d'une carte, a été établie. Cette fiche donne un certain nombre de renseignements généraux et dresse la liste des localités où le taxon a été observé pendant les vingt dernières années.

Idéalement, chaque localité mentionne le code I.F.B.L. (par carré de 1 km²), la nouvelle entité communale, l'ancienne commune, le lieu-dit, la date de la trouvaille, l'auteur de la trouvaille, la référence bibliographique dans laquelle la trouvaille a été signalée ou le code du fichier d'encodage de la donnée...

La carte reprend les données de l'Atlas 1979 (corrigées, si nécessaire) et les données récentes.

L'intérêt de cette méthode est de pouvoir compléter constamment les fiches et de modifier les cartes de distribution dès que cela s'avère nécessaire. Si de nombreuses données nouvelles relatives à un taxon nous parviennent (à la suite d'une étude ponctuelle, par exemple) la carte de distribution actualisée de ce taxon peut être dressée quasi instantanément.

A ce jour, plus de 600 taxons ont été traités: tous les taxons cités par Lawalrée et Delvosalle (1969); des plantes 'castrales' ayant une importance patrimoniale (*Tulipa sylvestris*, *Eranthis hyemalis*, *Hepatica nobilis*...); des plantes qui ont fait récemment leur apparition en Wallonie (*Buphthalmum salicifolium*, *Linum leonii*, *Dittrichia graveolens*...) et dont l'évolution doit être suivie; des taxons

intéressants à d'autres points de vue (adventices rares susceptibles de se naturaliser, plantes d'indigénat incertain, etc.); etc.

Les fiches relatives à ces taxons sont constamment complétées au fur et à mesure de la réception de nouvelles données.

Conclusion. Ces travaux ont permis:

- De dresser une Liste Noire (la liste des espèces disparues) (ce sont principalement des espèces des milieux humides, des messicoles, des espèces des landes...).
- De fournir tous les éléments nécessaires, les plus objectifs possible, à la sélection des taxons à faire figurer dans la Liste Rouge (cette sélection sera faite par une Commission désignée par le Conseil Supérieur wallon de la Conservation de la Nature, qui se réunira prochainement). Il s'agira de reprendre dans cette liste non seulement des taxons qui ont toujours été rarissimes chez nous (car en limite de leur aire de distribution par exemple), mais surtout d'y mentionner toutes les plantes qui étaient répandues ou assez répandues jadis, qui n'occupent plus actuellement que quelques localités (*Rhynchospora alba*, *Hypericum elodes*, *Thesium pyrenaicum*, *Hypochoeris maculata*...) et qui courent le risque de disparaître.
- D'attirer l'attention sur des espèces intéressantes à différents points de vue, mais qui ne devraient normalement pas figurer dans les catégories précédentes, ceci dans un but uniquement scientifique (*Sisyrinchium montanum*...).

Botanische biodiversiteit in soortenrijke cultuurgraslanden: methode en eerste resultaten

Heidi Demolder & Yves Adams

Instituut voor Natuurbehoud, Kliniekstraat 25, B-1070 Brussel, Belgium

heidi.demolder@instnat.be

Inleiding. Als gevolg van de intensivering van de landbouw werden de laatste decennia veel permanente, halfnatuurlijke graslanden in Vlaanderen omgezet in hoogproductieve, maar soortenarme, vaak tijdelijke (ingezaaide) graslanden of in akkerland. Halfnatuurlijke graslanden zijn in het huidige landschap zeer zeldzaam geworden tot nagenoeg verdwenen. Ze zijn meestal teruggedrongen tot natuurreservaten. Voor het natuurbehoud zijn dan ook deze graslanden waar nog een aantal relictten van halfnatuurlijke graslanden voorkomen, kortweg "soortenrijke (cultuur)graslanden" zeer belangrijk geworden.

Soortenrijke (cultuur)graslanden nemen een positie in tussen de halfnatuurlijke en soortenarme graslanden. Meestal gaat het om "overgangstypes" tussen halfnatuurlijke en soortenarme graslanden. Ze hebben veelal geen eenduidige vegetatiekundige afbakening. Soortenrijke (cultuur)-graslanden bezitten relictsoorten van de verschillende types van halfnatuurlijke graslanden, maar de echte kensoorten van de halfnatuurlijke graslanden ontbreken. Ze worden getypeerd door het voorkomen van soorten die wijzen op een minder intensief landbouwgebruik. Het betreft o.a. *Cynosurus cristatus*, *Anthoxanthum odoratum*, *Phleum pratense*, *Ranunculus acris*, *Cardamine pratensis*, *Rumex acetosa* en *Hordeum secalinum*.

Er is onvoldoende kennis voorhanden over de typering van soortenrijke cultuurgraslanden en over de factoren en processen die de kwaliteit van elk van deze types beïnvloeden. Vooral de variatie binnen de soortenrijke cultuurgraslanden en de ecologische factoren die deze variatie verklaren zijn slecht gekend. Daarom werd geopteerd om de diversiteit binnen deze soortenrijke cultuurgraslanden te onderzoeken en een aanzet te geven tot de ecotypologie van soortenrijke cultuurgraslanden.

Methoden. Tijdens de maanden mei en juni van 2000 en 2001 werden 375 vegetatieopnames (Londo-schaal, 3x3m) gemaakt over de verschillende geografische regio's in Vlaanderen. Door combinatie van deze vegetatieopnames met bodemdata, gegevens m.b.t het beheer, literatuur en auto-ecologische gegevens worden relaties met de omgeving voor de verschillende types soorten-

rijke cultuurgraslanden onderzocht. Op basis van de bekomen resultaten worden de verschillende types soortenrijke cultuurgraslanden beschreven.

Eerste resultaten. Onder soortenrijke (cultuur)graslanden verstaan we onder meer minder goed ontwikkelde mesofiele hooilanden en gedegradeerde dotterbloemgraslanden. Ook soortenarme heischrale graslanden en zilverschoongraslanden behoren tot de soortenrijke (cultuur)graslanden. Sommige soortenrijke (cultuur)graslanden worden gekenmerkt door dominantie van *Alopecurus pratensis* in de vegetatie. In een ander type is *Alopecurus geniculatus* aspectbepalend. Karakteristiek voor sommige soortenrijke (cultuur)graslanden is een uitbundige bloei van *Cardamine pratensis* in het voorjaar en van *Ranunculus acris* in de zomer. Het gaat hier om een minder goed ontwikkelde vorm met een lager soortenaantal in vergelijking met de bovenvermelde graslanden.

Temporal changes (1986-1999) in populations of primrose (*Primula vulgaris*) in an agricultural landscape and implications for conservation

Patrick Endels, Hans Jacquemyn, Rein Brys, Martin Hermy & Geert De Blust
KULeuven, Labo voor Bos, Natuur & Landschap, Vital Decosterstraat 102, B-3000 Leuven, Belgium
patrick.endels@agr.kuleuven.ac.be

Small landscape elements are believed to function as natural corridors between habitat patches in fragmented landscapes, but the extent to which they really act as corridors is still a subject of debate. However, ditches, hedgerows and other small landscape elements do function as important habitat refuges for the survival of many plant species from woodlands. Since habitat fragmentation and deterioration force an increasing number of plant species to survive in remnant (semi-)natural structures in the agricultural landscape, their importance is expected to increase. In Belgium *Primula vulgaris* Huds. is a rare and declining species. Its fate is bound up with the ever-changing agricultural landscape in North-Western Belgium and analysis of historical data showed a shrinking distribution area during the last decades. Contrary to the situation in England and France, most of the populations are situated in small landscape elements in the agricultural landscape and not in woodland. The population size distribution is skewed to very small populations (< 10 individuals) with few younger life stages in small populations, higher proportions of older adults and unequal flower morph numbers. The changes in several population traits during a 13-year interval are correlated with initial population status, indicating that small populations tend to be more prone to extinction than larger ones. Small remnant woodland patches may be seen as 'safe sites': in this environment population sizes were more or less stable during the 13-year period whereas populations in ditches around arable fields were particularly susceptible to decline. Under current conditions, the long term survival of the species in small landscape elements is highly critical unless land use practices change drastically in the near future. The minimum viable populations concept and management of small landscape elements are discussed.

Onderzoek naar het voorkomen van *Apium repens* in België

Anne Ronse & Leo Vanhecke
Nationale Plantentuin van België, Domein van Bouchout, B-1860 Meise, Belgium
anne.ronse@instnat.be

Kruipend moerasscherm (*Apium repens* Lag.) is een zeer zeldzame en bedreigde plant in België en elders in zijn verspreidingsgebied (*habitatrichtlijnsoort*). Aan de Nationale Plantentuin van België werd in 2000 een onderzoek gestart naar de verspreiding, ecologie en overlevingsmogelijkheden van deze soort. In een eerste fase werd de vroegere en huidige verspreiding onderzocht aan de hand van opzoeken in de IFBL- en FLO.WER-documentatie (streeplijsten), literatuur en herbaria en aan de hand van veldwerk. De grootte van de nog aanwezige plantenpopulaties werd bepaald

(geteld of geschat), en er werden een 60-tal vegetatiekundige opnamen gemaakt. Er werden ook standplaatsfactoren onderzocht om de auto-ecologische eisen (bodem, waterhuishouding) van de soort beter te leren kennen. Tenslotte werd ook kort de invloed van bodemgebruik en beheersmaatregelen onderzocht. In een volgende fase zal het onderzoek gericht zijn op het monitoren van de populaties of delen ervan en op het bepalen van de kritische factoren die verantwoordelijk zijn voor de zeldzaamheid en de hoge mate van bedreiging die op deze soort rust.

**Six-year permanent plot observation in nature reserves
submitted to restoration practices**

Sandrine Godefroid, Wim Massant, Gisèle Weyembergh & Nico Koedam
Vrije Universiteit Brussel, Department of General Botany and Nature Management (APNA),
Pleinlaan 2, B-1050 Brussel, Belgium; sagodefr@vub.ac.be

Vegetation data from permanent plots were collected from 1995 to 2000 in marshland, heathland and clear-felled forest vegetation from three nature reserves in the peri-urban Sonian Forest (Zoniënwood, Forêt de Soignes) in Brussels, where conservation and restoration practices have been performed since 1994.

Preliminary results of this study indicate that some nature management practices, such as mowing and flooding, combined with fencing against human ingress, can, after a very short lap of time, initiate the restoration of degraded vegetation types.

Mean species richness increased progressively and on average from 9.3 species/plot in 1995 to 14.6 in 2000 ($P=0.0014$). No significant changes appeared for a defined banality index, although a slight trend to decreasing banality was found.

At the individual species level, cover of some indicator species changed significantly. Competitive ruderal species, such as *Urtica dioica* and *Galium aparine* were affected by treatment and showed a decline. Some species typical of wetlands increased in abundance, such as *Angelica sylvestris*, *Lysimachia vulgaris*, *Lythrum salicaria* and *Epilobium parviflorum*.

The results of this study may contribute to the knowledge on species response against some conservation and restoration practices, and thus may be used to predict and evaluate long-term management effects. The particular problems of the peri-urban context are discussed.

Intermediaire Atlantische heide: de Natuurpunt-aanpak

Contact: Tom De Beelde & Jens Verwaerde

Natuurpunt vzw, Kardinaal Mercierplein 1, B-2800 Mechelen, Belgium

Intermediaire Atlantische heide (IAH) is een vegetatietype in Europa met een beperkt areaal (o.a. Oost- en West-Vlaanderen). Het areaal neemt evenwel af en ook de kwaliteit laat in veel gevallen te wensen over. De typische samenstelling van heiderelicten is vaak slechts een magere afspiegeling van de optimale samenstelling van dit biotoop. Natuurpunt heeft in 2000 een grootschalig, gebiedsdekkende inventarisatie uitgevoerd naar de verspreiding van dit vegetatietype. De informatie (soorten en biotopen) werd cartografisch opgeslagen en geeft een goed beeld van de toestand in de regio Brugge-Maldegem. Uit het onderzoek blijkt enerzijds de aanwezigheid van tal van heiderelicten (*Molinia caerulea*, *Calluna vulgaris*), maar anderzijds ook vaak het ontbreken van heel wat soorten (b.v. *Polygala serpyllifolia*, *Erica tetralix* en *Drosera rotundifolia* werden weinig teruggevonden). Niet alleen de verspreiding is fragmentair, de kwaliteit van de restanten laat ook vaak te wensen over. Nochtans bewijzen onze werkzaamheden in het Maldegemveld (te Maldegem, in het noordelijk deel van het Drongengoedcomplex) dat het met het juiste beheer wel degelijk mogelijk is om op vrij korte termijn (jaren) heidehabitats te herstellen en een aantal belangrijke soorten terug te krijgen vanuit de zaadbank. Een belangrijke referentie voor

dit soort beheerswerkzaamheden vinden we in het reservaat Gulke Putten, dat mag worden beschouwd als een referentiesituatie voor intermediaire Atlantische heide.

De poster licht een aantal concrete resultaten toe van het grootschalige verspreidingsonderzoek. Voorts wordt geïllustreerd hoe gerichte beheerswerkzaamheden in Maldegemveld hebben geleid tot snelle verbetering van de situatie, i.h.b. voor wat betreft de soortenrijkdom.

Freshwater diatoms and water quality in Flanders: an example from the Kleine Nete, a small lowland stream in Antwerp

Bart Van de Vijver & Louis Beyens

Universiteit Antwerpen (RUCA), Departement of Biology, Unit of Polar Ecology, Limnology & Paleobiology,
Groenenborgerlaan 171, B-2020 Antwerp, Belgium; bartvdiv@ruca.ua.ac.be

Freshwater diatoms are largely used as reliable bio-indicators for waterquality. Their potential to react accurately to changes, both in negative and positive way, in water quality makes the use of these micro-organisms in water assessment techniques quite valuable.

This lecture tends to give an idea of this use by presenting the results of a study conducted on the waterquality of the Kleine Nete, a small lowland stream in the Belgian province of Antwerp.

In the basin of this small river, six diatom assemblages could be distinguished, reflecting a qualitative and geographical zonation of the different parts of the river. A non-linear (i.e. parabolic) relationship has been established between the water quality, expressed by the scores of the various diatom indices, and the Shannon-Wiener diversity. Although the six diatom indices were significantly correlated with each other, only the Specific Pollution Index (SPI), the Descy's Index (IDC) and Leclercq & Maquet's Index (ILM) appeared to correlate best with the main ecological parameters of a river, i.e. eutrophication, organic pollution and salinity. The Commission of Economical Community Index (CEC) is highly correlated with the SPI, providing therefore a valuable alternative in monitoring the quality of running waters since the SPI is rather difficult due to the very precise taxonomical knowledge. Diversity indices are not suitable for using as water quality measures.

Het potentiële belang van ungulate endozoöchorie voor de verspreiding van plantensoorten

Maurice Hoffmann^{2,1}, Eric Cosyns¹, Sofie Claerbout¹ & Ward Vercruysse²

¹ Universiteit Gent, Vakgroep Biologie, Onderzoeksgroep Terrestrische Plantenecologie en Vegetatiekunde,
K.L. Ledeganckstraat 35, B-9000 Gent, Belgium; maurice.hoffmann@UGent.be

² Instituut voor Natuurbehoud, Kliniekstraat 25, B-1070 Brussel, Belgium; maurice.hoffmann@instnat.be

Inleiding. Om de biodiversiteit aan soorten te behouden of te herstellen worden door het natuurbeheer verschillende beheersvormen toegepast. In NW-Europa is de aandacht voor begrazing met gedomesticeerde herbivoren de laatste twee decennia sterk toegenomen. Ook in Vlaanderen is deze trend duidelijk merkbaar.

Door onze onderzoeksgroep wordt reeds een aantal jaren onderzoek verricht naar de effecten van extensief begrazingsbeheer op de vegetatie-ontwikkeling in de Belgische kustduinen. Uit dit onderzoek blijkt dat runderen, pony's en ezels de vegetatie niet alleen beïnvloeden door betreding, hun excretie- of graasgedrag maar evenzeer door de verbreiding van plantendiasporen via hun uitwerpselen (endozoöchorie).

Vraagstelling. Om het belang van endozoöchore zaadverbreiding te kunnen begrijpen, zijn we recent gestart met een onderzoeksproject naar de potentie tot zaadkieming vanuit uitwerpselen van verschillende herbivoren. Daarbij stelden we ons ondermeer volgende vragen:

- Zijn er überhaupt plantendiasporen aanwezig en, zo ja, van welke plantensoorten en in welke hoeveelheden komen er diasporen voor?

- Dient endozoöchorie dan als betekenisvol dispersiemechanisme toegevoegd te worden aan de meestal theoretisch veronderstelde (op de zaadmorfologie gebaseerde) dispersiemechanismen?
- Zijn er redenen om aan te nemen dat endozoöchorie belangrijk is als 'lange-afstands-dispersie' mechanisme?

Methode. Om deze vragen te kunnen beantwoorden zijn veertiendaags, van juli tot oktober 2000, van verschillende herbivoren en in verschillende kustduingebieden verse uitwerpselen (2,5 l/dier) ingezameld. De uitwerpselen zijn aan de lucht gedroogd en nadien voor tenminste 2 weken bij 4 °C bewaard. Na verbrijzeling is de mest in een dun laagje uitgespreid op een steriel kiemsubstraat (duinzand+compost).

Resultaten en besluit. Uit de mest kiemden over het algemeen een groot aantal kiemplanten (max.1161, min 167/staal). Het gemiddeld aantal plantensoorten per staal varieert tussen 12,71 en 31,33 plantensoorten. Over de hele onderzoeksperiode zijn het meest plantensoorten aangetroffen in de mest van Konikpony's (Westhoek, 71) en het minst in de mest van konijn (Ghyvelde, 31).

Vaak terugkerende soorten zijn *Urtica dioica*, vertegenwoordigers van Poaceae, Juncaceae en Cyperaceae, *Rumex acetosella* en *Veronica chamaedrys*.

Endozoöchorie blijkt een betekenisvol dispersiemechanisme te zijn voor o.a. Poaceae maar ook in het geval van specifieke anemochoren (*Senecio* spp.) en myrmecochoren (*Luzula campestris*).

Rekening houdend met de retentietijd van het voedsel in het spijsverteringsstelsel van de herbivoren en met de door hen afgelegde afstanden dient endozoöchorie als een (potentieel) belangrijk lange afstands dispersiemechanisme beschouwd te worden voor een aanzienlijk aantal plantensoorten. In projecten tot het herstel van de botanische diversiteit van natuurgebieden is niet alleen het herstel van een geschikt abiotisch milieu van belang ook moet rekening gehouden worden met de hervestigingsmogelijkheden van plantensoorten. Lange-afstandsverbredingsmogelijkheden kunnen daarbij van cruciaal belang zijn. De betekenis van endozoöchorie mag daarom niet onderschat worden.



Applied botanical research at the Institute for Forestry and Game Management (IBW-IFG, Flanders-Belgium)

Klaartje Van Loy & Kris Vandekerckhove

Institute for Forestry and Game Management, Gaverstraat 4, B-9500 Geraardsbergen, Belgium
author for correspondence: klaartje.vanloy@lin.vlaanderen.be

Abstract. – An overview is presented of research activities, related to vegetation sciences and botany, performed at the Institute for Forestry and Game Management. Special attention is given to how this scientific knowledge is implemented in management guidelines and practices. Presented topics are: methodology and results of intensive monitoring of vegetation dynamics in strict forest reserves; genetic and morphological diversity of plant species in water courses and the impact of planting them on the present flora; analysis of silvicultural and floristic data of the Flemish Forest Inventory; inventory and study of autochthonous woody plants and programs for in situ and ex situ conservation; influence of extensive grazing on forest species composition and vegetation structure; comparison of vegetation composition in new forest stands: active vs. spontaneous afforestation.

Samenvatting. – Toegepast botanisch onderzoek van het Instituut voor Bosbouw en Wildbeheer (IBW). Een overzicht wordt gegeven van de onderzoeksactiviteiten IBW in verband met vegetatiekunde en botanie. Hoe deze wetenschappelijke kennis om te zetten in beheersrichtlijnen en de beheerspraktijk krijgt speciale aandacht. Onderzoekslijnen zijn: methodologie en resultaten van intensieve monitoring van vegetatiedynamiek in strikte bosreservaten; genetische en morfologische diversiteit van plantensoorten in waterlopen en de impact van aanplantingen ervan op de aanwezige flora; analyse van bosbouwkundige en floristische gegevens van de Vlaamse bossen; inventarisatie en studie van autochthone houtachtige planten, en in situ en ex situ beschermingsprogramma's; invloed van extensieve begrazing van bossen op soortensamenstelling en vegetatiestructuur; vergelijking van de vegetatiesamenstelling in nieuwe bosbestanden: actieve versus spontane bosontwikkeling. Vertaald door de redactie.

Résumé. – Recherche botanique appliquée à l' 'Instituut voor Bosbouw en Wildbeheer' (IBW, Flandre, Belgique). Un aperçu des activités de recherche relatives aux sciences de la végétation et à la botanique poursuivies à l' Institut voor Bosbouw en Wildbeheer ('Institut pour l'Aménagement Forestier et Cynégétique') est présenté. Une attention particulière est accordée à la manière dont cette connaissance scientifique est mise en application dans les directives et les pratiques de l'aménagement. Les sujets présentés sont: méthodologie et résultats de la surveillance intensive de la dynamique végétale dans les réserves forestières intégrales; diversité morphologique et génétique des espèces végétales dans les cours d'eau et influence des plantations sur la

flore actuelle; analyse des données floristiques et sylviculturales de l'Inventaire Forestier Flamand; inventaire et étude des plantes ligneuses autochtones et programmes de conservation in situ et ex situ; influence du pâturage extensif sur la composition en espèces forestières et sur la structure de la végétation; comparaison de la composition de la végétation dans les nouvelles stations forestières: reforestation spontanée versus reforestation active. Traduit par la rédaction.

1 Introduction

The Institute for Forestry and Game Management (Instituut voor Bosbouw en Wildbeheer, IBW) (<http://www.ibw.vlaanderen.be>) aims to be the internationally recognized, central institute in Flanders, responsible for scientific research and scientific services, concerning greenery, forests, fauna, fish stock and their management. It was founded by a Flemish Government Decree on March 13rd 1991 as a scientific research institute, incorporating the former Government Poplar Research Station (located in Geraardsbergen) and the former Government Station for Sylvicultural and Hydrobiological Research (located in Groenendaal).

Today's scientific research focuses on forests, inland fish stock and fauna falling under special legislations (angling, hunting). Research topics have been identified in response to questions from forestry, inland fishery, nature conservation and hunting sectors, as well as from other research institutions. Other research is carried out in support of regional and European policy making.

The Institute has access to its own library, nurseries, seed orchards, climatised greenhouses, laboratories for in vitro, pedological, phytopathological, genetic and zoological research, a measuring unit for air pollution, a fish breeding centre, ...

Results of research activities are disseminated through articles in national and international journals, participation in seminars and meetings, organisation of study tours, excursions, advice... as well as through own publications: scientific reports, the annual activity report and the periodical 'Mededelingen'.

2 Research activities

2.1 Intensive monitoring of forest vegetation dynamics in strict forest reserves in Flanders: methodology and first results

Strict forest reserves in Central and Western Europe are mostly small (10-25 ha). Besides their nature conservation value, they are mainly conceived for the study of spontaneous forest dynamics. They therefore serve as an information-tool for better close-to-nature management of multifunctional forest outside the reserves.

A standard methodology for the monitoring of these stands was developed, based on experience and methods in neighbouring countries, and some own preliminary studies (Vandekerkhove & Van Den Meersschaut 1998, Vandekerkhove 2000). The system is based on permanent plots, combining a grid system with a core area. Every 10 years measurements will be repeated.

The time series of data from the circular plots will provide information on the development of the area as a whole, while as the study of the core area will provide more detailed information on the ecological processes within the stand (Vandekerkhove & al. 2001).

2.2 Genetic and morphological diversity of three plant species of water-courses and the impact of planting of these species on the present flora

When (river)banks are artificially planted, the critical question is raised, by directly or indirectly involved parties, whether these measures are soundly based. Particularly whether the present and

possible autochthonous vegetation will become endangered in time. Not in the least the attention has been drawn to the possible negative consequences of the phenomenon of 'genetic pollution'.

To clear this matter up a 'TWOL'-research (Applied Scientific Research in Environment) was started at the Department for Plant Genetics and Breeding (Agricultural Research Centre, CLO), in cooperation with the Institute for Forestry and Game Management and acting upon instructions from the Forests and Green Spaces division (Afdeling Bos & Groen).

The research has to lead to provide knowledge in the use of ecologically reliable basic material. In time it is desirable that plants will be available on the market, which cover certain, still to be made, 'ecological standards'.

Three plant species (*Phragmites australis*, *Typha latifolia*, *Iris pseudacorus*) have been selected for research on their morphological and genetic diversity.

Phragmites plants from different locations were placed in uniform growth conditions to measure morphological characteristics and to be compared with plants in natural vegetation.

Clonal plant populations are often supposed to consist of only few genotypes. Results for *Iris pseudacorus* have shown that within the studied locations in Flanders still a large potential of genetic diversity is present (Lamote & al. 2001b). It is also suggested that clonal and sexual reproduction both occur in *Phragmites australis* populations in the estuary of the Schelde River (Lamote & al. 2001a).

2.3 Analysis of silvicultural and floristic data from the Flemish Forest Inventory

To conduct an efficient forest policy, accurate and recent data concerning the basic characteristics of the forest are needed. That is why during the period of 1997-2000 the first Flemish Forest Inventory was completed.

After a first processing of the data the most important results were published in a final report (Afdeling Bos & Groen 2001). Further statistical analysis and scientific processing has been done at the Institute for Forestry and Game Management.

An important contribution of the forest inventory data was made to the 'authenticity index', developed by Van Den Meersschaut & al. (2001). The main aim of this project was to produce a standardised and practical methodology for the monitoring of some important aspects of biodiversity in forests. A scoring system for stand structure, species composition of herbal and woody layer and dead wood was developed, based on the forest inventory dataset.

The results proved the index to be sensitive to changes due to management and to be reflecting the actual diversity (structural and compositional) of forests.

The index values for all of the sample plots of the forest inventory varie mostly between 20-50/100. Particularly low values are calculated for dead wood and woody layer. Nevertheless some plots can reach the maximum for one aspect of the authenticity index.

Through the direct link with the forest inventory, the index is a useful and practical tool for the monitoring of the overall performance of management measures and policies on some important aspects of forest diversity (Vandekerkhove & al. 2001, Van Loy & Vandekerkhove 2001).

2.4 Inventory and study of autochthonous woody plants and programs for *in situ* and *ex situ* conservation

Many trees and shrubs are planted for reasons of nature conservation and landscape design. It is therefore important to carefully watch over the use of autochthonous planting material.

An autochthonous tree or shrub has regenerated only spontaneously since the last ice age or has been propagated by man using local original plant material. Strictly spoken, native woody plants that are imported from a different climatic zone or geological area are not autochthonous.

The growth sites of autochthonous trees and shrubs in Flanders and their quality have drastically been reduced over the last decades. Obvious reasons are the process of intensive forest-use and deforestation in the past centuries and more recently the agricultural scale enlargement.

Less known is the import of seeds from native species, but of foreign origin. Forest reproductive material is often grown from seeds that originate from East and South Europe, where cheap labour is at hand. These woody plants are less adapted to the Flemish growth conditions because of their remote origin. They can flower too early, grow too fast, be more sensitive to diseases,... By the spread of foreign genes, they can influence the genetic constitution of local autochthonous populations of the same species.

Inventory of autochthonous trees and shrubs in Flanders is a first step towards their conservation and use. The inventory opens possibilities to in situ and ex situ conservation of autochthonous gene resources. The Flemish Community invests in the harvesting of autochthonous seeds, to create autochthonous plant material, and in scientific research on genetic diversity of autochthonous populations (Coart & al. 1998, Vander Mijnsbrugge 2001).

2.5 Influence of extensive grazing on forest species composition and vegetation structure

The aims of this research is to study the effects of extensive grazing on species composition and vegetation structure in relation to forests, through monitoring of a number of small case-studies. Permanent quadrats (PQ's) and circular nested plots are marked out to follow the changes in vegetation over time, both in composition and structure, with special attention to forest regeneration and forest structure. Three distinct case-studies are monitored up to now:

- in the forest reserve 'Grootbroek' (Kinrooi) a primarily open area of 20 ha (of which 5 ha of forest) is grazed in the summer-season by cattle (3-4 animals);
- at the military domain 'Kamp van Beverlo' (Leopoldsburg), 100 ha of mostly homogeneous pineforest is grazed in summer by cattle (6 animals);
- in nature reserve 'Altembroek' (St-Martens-Voeren), on 70 ha consisting of abandoned arable land, meadows and patches of ancient woodland, the effects of year-round grazing (8 animals) are monitored, with special attention to ancient woodland indicator plant species.

2.6 Comparison of vegetation composition in new forest stands on formerly intensive agricultural lands: active vs. spontaneous afforestation

When farmland is converted into forest, most of the time artificial afforestation is preferred over spontaneous forest development. This causes a lot of controversy and discussion among nature and forest managers. From a nature conservation point of view the advantages and disadvantages of spontaneous afforestation have been insufficiently documented with Flemish research.

The goal of this project is to find out the differences between spontaneously forested and artificially afforested farmland with regard to vegetation structure and species composition of the herbaceous layer. The method consists of selecting a number of representative sites, where both a spontaneous and an artificial afforestation on former farmland are found, under the same growth conditions. A distinct is made between several soil types. For each of these soil types at least one case study has been elaborated. The vegetation in the sites is inventoried in permanent sample plots. Measurements on stand structure and amount of light are performed. Also a mixed soil sample is taken in every sample plot.

Besides the comparing research, a GIS-database is built with all known spontaneous afforestations in Flanders (Verstraeten & al. 2001).

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L'A.E.F. et l'expertise botanique en région wallonne et en région de Bruxelles-Capitale

Philippe Martin

Secrétaire de l'Amicale Européenne de Floristique (A.E.F.), rue de Fosses 7H B-5150 Floreffe
aef.se@belgacom.net

Résumé. – L'AEF, l'Amicale Européenne de Floristique, présente ses réalisations dans le domaine de la floristique au cours des 10 années écoulées. L'A.E.F. a élaboré une liste floristique à lecture optique reprenant les noms abrégés, cochables sur le terrain, de 1700 taxons. Cette liste est basée sur la dernière édition de la 'Nouvelle Flore' de De Langhe et al. (1993). Cette liste est associée à un programme de saisie et à un programme de gestion informatiques exploitables sur PC. Deux million de données sont dès à présent enregistrées et analysables, notamment pour les recherches sur la distribution des espèces. La revue de l'A.E.F., *Adoxa*, fait état de l'expertise de ses collaborateurs dans les domaines de la floristique, de la conservation et de la protection des espèces et des sites, qui se concrétisera par la publication prochaine de la 'Liste Rouge des espèces menacées de Wallonie'. L'article déplore l'abandon de la botanique de terrain dans les universités et met en garde contre les dangers liés à la disparition de cette science. Il évoque le futur de la floristique belge en épinglant les problèmes qui se posent actuellement. Rédigé par la rédaction.

Samenvatting. – De A.E.F. en de botanische expertise in het Waals en het Brussels Hoofdstedelijk Gewest. De A.E.F, Amicale Européenne de Floristique, stelt de resultaten voor van 10 jaar floristisch onderzoek betreffende de vaatplanten. De A.E.F. heeft een optisch leesbare, floristische streeplijst gemaakt met de afkortingen van 1700 taxa. Deze lijst is gebaseerd op de laatste uitgave van de 'Nouvelle Flore' van De Langhe et al. (1993). De lijst is gekoppeld aan een invoerprogramma en een verwerkingsprogramma voor PC. Twee miljoen gegevens werden geregistreerd en zijn beschikbaar voor analyse, o.a. voor onderzoek naar de verspreiding van de soorten. Het tijdschrift van A.E.F., *Adoxa*, neemt bijdragen op van de medewerkers op het vlak van floristiek, behoud en bescherming van soorten en sites, die leiden tot de in voorbereiding zijnde Rode Lijst van bedreigde planten in Wallonië. Deze bijdrage hekelt de teloorgang van het botanisch veldwerk aan de universiteiten en wijst op de gevaren van het verdwijnen van deze tak van de wetenschap. Tenslotte worden nog enige bedenkingen geformuleerd over de toekomst van de floristiek in België aan de hand van de problemen van vandaag. Vertaald door de redactie.

Abstract. – **The A.E.F. and the botanical expertise in the Walloon and Brussels Capital Region.** *The A.E.F, Amicale Européenne de Floristique, presents its floristic activities on vascular plants during the last decade. A machine readable floristic annotation list for field surveys has been made with the abbreviations of 1700 taxa, based on the latest edition of the 'Nouvelle Flore' of De Langhe et al. (1993). The list is coupled to an input and a data management programme for PC. Two million data are registered and available for analysis now, e.g. for the study of the distribution of species. The journal of A.E.F., Adoxa, presents work from collaborators in floristics, conservation and protection of species and sites, ultimately leading to the Red List of endangered plants in Wallonia. The article regrets the abolishment of botanical field work at the universities and points to the dangers involved with the disappearance of this scientific discipline. Finally the problems of today and the futur of floristics in Belgium are evoked.* Translated by the editors.

Introduction

Depuis près de 10 ans, l'Amicale européenne de floristique (A.E.F.) poursuit l'étude de la flore wallonne et bruxelloise, travail qui avait été initié au niveau national par l'Institut floristique belgo-luxembourgeois (IFBL), et qui avait placé la Belgique au rang des précurseurs de la cartographie floristique, dans la foulée de l'Institut de Floristique belge, créé dès 1939.

La liste floristique et le programme de gestion

Une des premières réalisations de l'association fut la rédaction d'une nouvelle liste floristique (fig. 1). En effet, l'actualisation de la dernière liste en vigueur datant de 1973 et se basant sur la première édition de la Nouvelle Flore de Belgique (De Langhe & al. 1973), s'imposait. Cette nouvelle liste floristique se réfère à la 4^e édition de la Nouvelle Flore (Lambinon & al. 1993). Elle couvre non seulement l'ensemble du territoire belge mais aussi le sud des Pays-Bas, la zone limitrophe de l'Allemagne et le Nord de la France, y compris la Normandie. Cette dernière extension assure le lien avec le territoire couvert par l'Institut de Floristique franco-belge (IFFB).

La liste est originale par son écriture rationnelle qui permet de positionner les noms scientifiques abrégés de quelque 1700 taxons en un format A4 et dans un système de colonnes orthonormées, et donc potentiellement exploitable en lecture optique. Son originalité tient aussi au fait d'être associée à un programme de saisie de type déroulant et exploitable sur un PC, qui en permet l'encodage précis et rapide (fig.2). Ce même programme permet également l'enregistrement des données contenues dans tous les types de documents, y compris les manuscrits.

Ensuite, c'est un programme de gestion de la base de données ainsi créée qui fut élaboré. Actuellement, l'insertion de près de 5000 relevés constitue une masse d'un demi-million de données et permet une analyse par région ou par taxon, des synthèses et des recherches relatives à la distribution des espèces rares.

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Figure 1. Fac-similé de la liste floristique.

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Souris : gauche = PageUp, droite = PageDown, les deux = Enter
Enter = saisir/effacer un taxon, F1 = enregistrer la liste, ESC = abandonner

Figure 2. Première page du programme de saisie associé à la liste floristique.

L'expertise et la prospection floristiques

L'A.E.F. c'est aussi, comme de nombreuses associations à vocation naturaliste, une plate-forme d'échange d'informations botaniques, lors d'excursions régulières qui proposent des prospections originales ou une approche didactique. Ces informations sont éditées dans la revue de l'association, ADOXA qui fait état également des expertises de ses collaborateurs, de thèmes de floristique générale, de conservation de sites importants en Wallonie ou de protection de taxons menacés.

Cette protection des végétaux, qui nous tient tous à cœur, vient de se concrétiser par un travail de grande ampleur, dont les données ont été rassemblées par Jacqueline Saintenoy-Simon: la liste rouge des plantes menacées en Wallonie, qui doit faire l'objet d'une publication sous peu. De cette liste, le Conseil Supérieur Wallon de la Conservation de la Nature a extrait un ensemble de taxons qui doivent être soumis aux autorités compétentes afin d'élargir le champ d'action de la loi régissant la protection des végétaux datant de 1976.

Le bilan de cette décennie est donc très positif, mais la tâche à accomplir reste énorme, malgré l'ampleur du travail déjà effectué précédemment: l'atlas de van Rompaey et Delvosalle (1979) en est le témoin exemplaire.

Les botanistes de terrain

L'évocation des avancées encourageantes, sinon des succès, ne doit pas toutefois occulter les problèmes auxquels est confrontée notre association, à l'instar de beaucoup d'autres groupements homologues d'ailleurs, et je voudrais profiter de cette tribune pour les évoquer brièvement.

Problème de fond, tout d'abord. Paul Fournier, en 1935 déjà, évoquait les malheurs de la botanique descriptive (Fournier, 1935). Que dirait-il aujourd'hui, devant une situation sans précédent qui voit la plupart des facultés universitaires abandonner la botanique de terrain et la plupart des sciences descriptives les unes après les autres? Que dirait-il devant le désintérêt total de l'enseignement, à tous les niveaux, de ces mêmes sciences que sont la floristique, l'entomologie, la mycologie, où les spécialistes de terrain deviennent des curiosités.

Le pragmatisme économique a placé la biologie moléculaire au devant de la scène scientifique. Certes, il serait inconséquent de nier l'importance d'une discipline qui conduit l'esprit humain au cœur même de la vie. L'étude des végétaux n'y échappe pas et cette nouvelle approche proposera certainement un regard nouveau et intéressant sur la systématique. La crise de la biodiversité évoquée par d'autres orateurs y trouvera-t-elle une solution? C'est peu probable, non à défaut de moyens techniques ou financiers, mais simplement parce la biologie moléculaire semble bien loin des réalités de terrain. Les électrophorèses chères à nos amis généticiens ne feront guère évoluer la cartographie floristique ou faunistique.

Les études d'incidence demandées par exemple par les pouvoirs locaux sollicitent le concours de nombreux biologistes de terrain, dont des botanistes capables d'effectuer des relevés fiables, sur base d'une bonne connaissance de la flore. Où l'apprennent-ils aujourd'hui?

Les naturalistes sont donc devenus des poètes, de doux rêveurs dont on se demande s'ils ne sont pas nés un siècle trop tard, et dans la foulée, l'herbier, fleuron d'une science désuète, ressemble à un aimable divertissement. Aussi, face à la phagocytose de la biologie descriptive, les seuls encore «actifs» seront peut-être les particuliers ou les professionnels retraités, qui ne craignent guère les rabotages et compressions de budgets, étant leurs propres pourvoyeurs de fonds.

La dérive qui résulterait de cette tendance serait préjudiciable pour le futur, par la fracture qui apparaîtrait inévitablement dans la diffusion d'une science dont la transmission orale est certes fondamentale, mais qui demande des structures et des moyens importants pour en assurer la pérennité. Comment ne pas évoquer à ce propos les termes désabusés mais si justes du président de la Société botanique de France, B. Descoings, parlant de la «désolante aberration d'une civilisation qui laisse périr en toute conscience sa mémoire scientifique et des richesses patrimoniales dont la valeur s'accroît à mesure que les végétations et les flores de notre globe disparaissent...» (Descoings, 1988)

Dans ce contexte, permettez-moi de m'interroger aussi sur le sens et l'adéquation du terme «amateur», consacré par l'usage mais bien impropre. Au sens premier, amateur, du latin «amare», aimer, désigne quelqu'un qui a un intérêt particulier pour quelque chose. Cela s'applique évidemment au botaniste dit «amateur» comme au botaniste professionnel. On oubliera le sens du terme amateur, péjoratif, celui dont le zèle fait défaut dans la pratique d'une discipline... Dans une troisième acception, le mot s'adresse à celui qui pratique une discipline pour son agrément (pour son seul plaisir, sans destination utilitaire, précise le dictionnaire). Au-delà d'un débat d'ordre sémantique, s'il y a l'usage établi, il y a sûrement un cloisonnement réducteur qui n'apporte rien à la Botanique. En l'absence de floristes professionnels, faudra-t-il croire que la protection des végétaux rares ou menacés, que la gestion et le maintien des biotopes protégés est de l'ordre de l'agrément?

Quel futur pour la floristique belge ?

D'autres problèmes, encore plus concrets, surgissent aujourd'hui. Épinglons quelques raisons.

L'évolution de la flore d'un pays où la démographie et l'urbanisation sont parmi les plus fortes d'Europe occidentale impose une prospection continuelle. Les transformations du territoire affectent souvent les biotopes les plus riches et les plus fragiles, avec une régression sensible des espèces rares ou menacées. Les activités humaines génèrent également des introductions dont l'ampleur dans le temps et l'espace est particulièrement visible sur les cartes floristiques.

Un territoire aussi exigu que celui de la Belgique, et a fortiori celui de la Région wallonne, pourrait faire croire que son analyse floristique peut être bouclée en quelques années et en donner un instantané appréciable. Avec la résolution kilométrique utilisée par le quadrillage IFBL, une étude en 5 ans de la cartographie floristique de Wallonie demanderait la mise en œuvre de quelque 3700 relevés par an. A raison d'une équipe de 20 prospecteurs, cela représente plus de 180 relevés par personne et par an. Illusoire, bien sûr.

A cela s'ajoutent des difficultés techniques liées aux changements cartographiques engagés par l'Institut géographique national. Quel sera l'avenir du quadrillage IFBL par rapport au système UTM, plus convivial au niveau européen et largement utilisé dans d'autres disciplines de la biogéographie mais dont les algorithmes de transferts posent de sérieux problèmes, notamment à l'Est du pays en raison de la divergence des fuseaux ? Quel sera l'apport du GPS, ou encore l'accès aux cartes numériques ? Quel sera le potentiel des archives dans ces perspectives ?

Et que dire des moyens financiers dérisoires mais vitaux pour nos fragiles associations, dont la quête est récurrente et à l'origine d'une perte considérable de temps et d'énergie.

Enfin, il faut évoquer le vieillissement des effectifs des associations, où les quadragénaires sont souvent les plus jeunes. Les causes de ce déséquilibre démographique sont bien sûr liées au contexte actuel de la biologie descriptive.

Il reste énormément de projets, bien des perspectives et les défis ne manquent pas, ni les difficultés. Nous nous devons d'être optimistes, c'est notre raison d'être, mais aussi lucides.

Nous devons demander aux décideurs de ce pays d'assurer les moyens d'une politique exigée par la société dans sa prise de conscience du concept de biodiversité. Récente et fondamentale, cette notion est une réalité heureusement incontournable aujourd'hui et il nous incombe non seulement d'y travailler ensemble mais aussi de présenter un front uni, au Nord comme au Sud, particuliers et professionnels, pour exiger les moyens nécessaires. Ce sera la seule façon de parvenir à un résultat qui puisse être apprécié par les générations futures.

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FLO.WER (Floristische Werkgroepen) en het Vlaamse Atlasproject

Dirk De Beer

Amerikalei 214, B-2000 Antwerpen; Dirk.debeer@pih.provant.be

Samenvatting. – *FLO.WER ontstond in 1993 uit het IFBL en beheert en coördineert de floristische informatie voor Vlaanderen. FLO.WER vormt een belangrijke schakel tussen de overheid, verenigingen en vrijwilligers. Samen met verschillende instituten en instellingen is Florabank opgericht, een floristische databank die momenteel 1,8 miljoen data bevat. Deze databank wordt veelvuldig geraadpleegd voor allerlei studies en biedt meer mogelijkheden dan het opmaken van verspreidingskaarten. Voor 2004-2005 wordt de uitgave van een nieuwe atlas gepland. Met het oog hierop worden in 2002 de laatste leemten opgevuld via het 'hokken-adoptieprogramma'.*

Abstract. – *FLO.WER (Flemish Floristic Working Groups) and the Flemish Atlas project. FLO.WER was founded in 1993 from the splitting up of the former national IFBL into a Flemish and a French speaking part. It manages and coordinates the floristic information on vascular plants in Flanders. FLO.WER is an important intermediary platform between governmental administrations, associations & working groups and the volunteers. Florabank, a floristic database with about 1.8 million data, is an initiative between several institutes and institutions and is managed through FLO.WER.. This database is regularly consulted for study purposes and offers many possibilities apart from generating distribution maps. A new atlas of the Flemish flora is planned for 2004-2005. Translated by the editors.*

Résumé. – *FLO.WER (Groupes de travail Floristiques Flamandes) et le projet d'Atlas Flamand. FLO.WER est né en 1993 de l'IFBL et gère et coordonne l'information floristique en Flandre. FLO.WER constitue un lien important entre le gouvernement, les associations et les amateurs. Conjointement avec divers instituts et institutions a été élaborée Florabank, une banque de données floristiques qui actuellement compte 1,8 millions de données. Cette banque de données est fréquemment consultée pour diverses études et offre davantage de possibilités que la réalisation de cartes de distribution. L'édition d'un nouvel atlas est planifiée pour 2004-2005. C'est dans ce but qu'en 2002 ont été comblées les dernières lacunes. Traduit par la rédaction.*

Beknopte historie

De floristiek in België heeft al een lange traditie. In 1939 werd het IFB opgericht (Instituut voor de Floristiek van België), later met het Groothertogdom Luxemburg uitgebreid tot IFBL. Als resultaat van deze werking werd in 1972 de eerste atlas van de Belgische flora uitgegeven (Van Rompaey & Delvosalle 1972). In 1979 werd een tweede, licht aangepaste versie van de atlas gepubliceerd.

Na het uiteenvallen van het IFBL, werd in 1995 de v.z.w. FLO.WER opgericht. FLO.WER erfde de oude IFBL-archieven voor het Vlaamse landsgedeelte en stond voortaan in voor de coördinatie van het floristisch onderzoek in Vlaanderen. Voor Wallonië en het Brusselse Gewest gebeurde dit voortaan door onze zustervereniging AEF (Amicale Européenne de Floristique).

Doelstellingen

FLO.WER heeft als doelstelling het beheren en coördineren van floristische informatie en activiteiten, alsook het stimuleren van allerlei floristische activiteiten, met de bedoeling de kennis betreffende de Vlaamse flora te vergroten. Verder speelt de vzw een belangrijke rol in de contacten tussen individuen, verenigingen en instituten die begaan zijn met de floristiek.

Belangrijke partners voor het realiseren van de doelstellingen van FLO.WER zijn bijvoorbeeld het Instituut voor Natuurbehoud, de Nationale Plantentuin, de Rijksuniversiteit Gent en AMINAL afdeling Natuur. Daarnaast zijn van lente tot najaar talrijke 'strepers'¹ actief bezig met het inventariseren van planten, zowel individueel (in hun vrije tijd) als in groep (in het kader van de activiteiten van allerlei natuurverenigingen). Na de fusie van Natuurreservaten en De Wielewaal wordt gehoopt dat in de toekomst ook de grote nieuwe vereniging – Natuurpunt – in deze structuur een belangrijke plaats zal innemen (b.v. in verband met monitoring in reservaten).

Florabank

Van bij de oprichting is ernaar gestreefd zowel de oude IFBL-archieven als de nieuw binnengekomen gegevens in één grote digitale databank onder te brengen. Dit werd in de praktijk mogelijk gemaakt dank zij twee VLINA-projecten. Thans bevat deze databank (Florabank) ongeveer 1,8 miljoen gegevens.

Aanvankelijk werd enkel gedacht aan het opmaken van verspreidingskaarten, maar al spoedig is gebleken dat de databank ook tal van andere analyses mogelijk maakt. In het kader van de VLINA-projecten werden studies uitgevoerd over de wijzigingen in de flora in Vlaanderen, de zeldzaamheid en kwaliteit van ecotypen en de evolutie van deze ecotypen in de loop van de tijd. Verder wordt de databank door diverse aanvragers – zowel individuele personen als instellingen en studiebureaus – frequent geconsulteerd voor het bekomen van basismateriaal voor terreinstudies of studies van taxonomische groepen.

¹ Het woord 'streper' – net zoals het werkwoord 'strep' – verwijst naar de wijze waarop de inventarisatiegegevens van hogere planten in het veld worden vastgelegd, namelijk door het diagonaal doorstrepen van de afkortingen van de namen van de gevonden plantensoorten op voorgedrukte formulieren, die Flo.Wer ter beschikking stelt van de inventariseerder.

De modaliteiten i.v.m. de eigendom van de gegevens en het ter beschikking stellen ervan zijn vastgelegd in een overeenkomst tussen de vzw en haar leden, die een groot gedeelte van de gegevens voor Florabank hebben verzameld en aangeleverd. Deze overeenkomst bepaalt dat de aanbrengrer van de gegevens eigenaar blijft van zijn of haar gegevens en er ten volle blijft over beschikken. FLO.WER is mede-eigenaar en bepaalt welke gegevens in welke vorm (b.v. graad van detail) aan derden kunnen ter beschikking gesteld worden. Veelal verstrekt Flo.Wer de gevraagde gegevens op grond van een uitwisselingsakkoord, d.w.z.: de aanvrager engageert zich ertoe om, na beëindiging van zijn onderzoek, de door hem nieuw verzamelde verspreidingsgegevens ter beschikking te stellen voor opname in Florabank. Momenteel worden meer gegevens aangeleverd via uitwisseling dan door de leden zelf!

Atlasproject

Na het verschijnen van de eerste Belgische plantenatlas (Van Rompaey & Delvosalle 1972) werd begonnen met een tweede inventarisatieronde. Recent is beslist om deze ronde eind 2002 af te sluiten. Aan de hand van de gegevens die tot eind 2002 in het veld verzameld worden en ingebracht worden in Florabank, zal een nieuwe verspreidingsatlas van de hogere planten in Vlaanderen uitgegeven worden. Bedoeling is om dit boek in 2004 of 2005 gepubliceerd te krijgen.

Het onderzoek is momenteel al ver gevorderd en laat stilaan toe een behoorlijk beeld te schetsen van de verspreiding van de hogere planten in Vlaanderen. De inventarisatiegraad ligt in ieder geval een stuk hoger dan bij het tot stand komen van de eerste editie van de atlas. Het heeft trouwens ook weinig zin om de finalisering van het project nog langer uit te stellen, vermits de wijzigingen in de flora zo snel gaan.

Basis voor het onderzoek is, net als in de Belgische plantenatlas uit 1972, het IFBL-raster, dat het hele grondgebied van Vlaanderen bedekt. Het streefdoel is om per uurhok (een vierkant van 4 x 4 km) minstens vier inventarisatielijsten (zgn. streeplijsten) van kwartierhokken (1 x 1 km) te realiseren, met als bijkomende voorwaarde dat op elke streeplijst minstens 100 soorten moeten aangestreept zijn. Om dit doel te bereiken is in 2002, het laatste jaar van het veldwerk, nog een kleine extra inspanning nodig. Teneinde de krachten optimaal te bundelen en de taken efficiënt te verdelen, is een hokken-adoptieprogramma tot stand gebracht, dat kan geraadpleegd worden op de website van het Instituut voor Natuurbehoud. Een overzichtskaart biedt een overzicht van al de hokken die nog niet voldoende geïnventariseerd zijn, met vermelding van het aantal streeplijsten dat nog moet binnengebracht worden om de norm van 4 lijsten per uurhok te halen. Bedoeling is dat de terreinwerkers met behulp van de overzichtskaart een keuze maken van de hokken die zij in 2002 wensen te 'adopter' en te inventariseren. De stand van zaken van geadopteerde hokken wordt op de website bijgehouden en geregeld bijgewerkt, zodat iedereen kan zien waar nog extra inspanningen gewenst zijn.

Andere projecten

Behalve met het strepen van kilometerhokken, houden de leden van FLO.WER zich ook nog bezig met ander onderzoek, b.v. betreffende de verspreiding en eventuele inburgering van niet-inheemse planten (adventieven, recent ingeburgerde soorten, potentiële inburgeraars). Speciale aandacht is bijv. voor de flora van maïsakkers en de dikwijls zeer soortenrijke flora in en rond de steden. In *Streepzaad*, het mededelingenblad van FLO.WER, worden geregeld determinatie-

sleutels gepubliceerd die het op naam brengen van recent in opmars zijnde planten, zoals de grassen van de geslachten *Panicum* en *Setaria*, gemakkelijker maken. In de toekomst zal op dit vlak van publicaties nauwer samengewerkt worden met *Dumortiera*, het door de Nationale Plantentuin uitgegeven floristische tijdschrift.

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The Belgian Dendrology Society

Dirk De Meyere

National Botanic Garden of Belgium, Domein van Bouchout, B-1860 Meise
Dirk.Demeyere@br.fgov.be

Abstract. – *The contribution by a society of dedicated amateurs to the conservation of the biodiversity of the tree heritage of parks and botanical collections is illustrated by an overview of the society's objectives, historical background, scientific activities and publications. Objectives and results of the tree inventory of Belgium (BELTREES) are discussed.*

Samenvatting. – *Objectieven, historiek, wetenschappelijk gerichte activiteiten en publicaties illustreren de bijdrage die een vereniging van toegewijde amateurs kan leveren tot het behoud van de biodiversiteit van het bomenpatrimonium van botanische collecties en parken. De doelstellingen en de resultaten van de bomeninventarisatie van België (BELTREES) worden besproken.*

Résumé. – *L'exposé des objectifs, de l'historique et des activités scientifiques déployées par une société d'amateurs éclairés donne un aperçu de la contribution que celle-ci peut apporter à la conservation de la biodiversité du patrimoine constitué par les arbres dans les parcs et collections botaniques. Les objectifs et résultats de l'inventaire des arbres de Belgique (BELTREES) sont discutés.*

1 Objectives

The purpose of the society is to provide a meeting possibility for all those who are interested in trees and shrubs and who wish to improve their knowledge about these plants and their cultivation. The society wishes to reach as many people as possible and to contribute to the conservation of woody plant species in their natural habitat and in botanical parks and gardens.

2 Historical background

J. & R. De Belder, R. Lenoir, Ch. de Limburg Stirum, and A. de Radzitzky d'Ostrowick, all members of the International Dendrology Society, which was founded the previous year, established the society in 1953 (Lenoir 1967). The society has enjoyed a significant development

since 1988 under the leadership of Ph. de Spoelberch, M. Decalut and J.-C. Baudouin. An active Board of Directors has contributed to extend the number of activities. As a consequence, membership increased from 50 to some 500 members. The first contact with its members was achieved through the bi-annual contact letter 'Belgische Dendrologie Belge', edited by M. Decalut. Originally an informal society, the society was incorporated in 1993 as a Belgian non-profit organisation. From 1994 onwards the contact letter has been replaced by a quarterly Newsletter (in two national languages) and a Yearbook. R. Jacobs, being the editor/publisher of the yearbook, was joined by D. De Meyere in 1997, who eventually became chief editor in 2000.

3 Scientific Activities

The society attempts to reach its objectives by a number of activities, such as workshops, excursions, making inventories of dendrological collections and giving management suggestions.

3.1 Conferences and workshops

Traditionally, during the winter months, a conference is organised which brings members together around various subjects such as a review of the past year's activities or study tours, and discovery of remarkable trees.

Each year a workshop is devoted to a single genus. The presentations cover the subjects of systematics and taxonomy, propagation and cultivation and the use of the species and main cultivars in horticulture and gardening. In order to cover in depth the botanical aspects of the specific genus, the society frequently calls upon the talent of international specialists [1991: *Tilia* (Dr. P. de Jong, NL); 1992: *Acer*; 1994: *Ilex* (Dr. S. Andrews, UK); 1995: *Magnolia*; 1996: *Aesculus* (Dr. P. de Jong, NL); 1997: *Viburnum*; 1998: *Cornus* (Prof. Dr. P. Goetghebeur, BE); 1999: *Sorbus* (Dr. H. McAllister, UK); 2000: *Azalea* (Dr. K. Kron, USA)]. After the theoretical presentations, a field trip to a specialized collection allows members to discover the characteristics of the genus.

3.2 Study tours and excursions

Knowledge about trees is mainly acquired in the field and the main thrust of activities of the society is devoted to the visits to natural sites or botanical collections in Belgium and abroad. The society organises approximately five day trips allowing for the visit of two or three gardens or natural sites per day. The study tour on the contrary lasts from three to six days, allowing members to visit remarkable plant collections and trees growing under various climate conditions. Since 1989, study trips have visited the following countries: Republic of Czechoslovakia (1994), France (1992; 1997; 1999: Ile of France), Germany (1989; 1990; 1999: Bavaria), Italy (1996: Tecino), Switzerland (2001: Geneva), Luxemburg (1995), Ireland (1993), The Netherlands (1993, 1998), Great Britain (1991 & 1996: England; 1995: Scotland; 1998: Cornwall), United States of America (1992: North Carolina; 1997: New England).

3.3 Cataloguing dendrological collections

One of the first objectives of the society was to establish inventories of trees in Belgium. Many partial inventories by park or region had been published in the past by various organisations, but it was in 1987 that the Belgian Dendrology Society started on a systematic inventory of important dendrological parks of Belgium. The cataloguing took six years. It would not have been completed without the energy of several members, among which J.-C. Baudouin whose huge amount of fieldwork, within the framework of his professional activities with the Belgian State and later the Walloon Region, allowed to complete the inventory of approximately 500 parks. He was helped by Ph. de Spoelberch and several other members. The findings of the inventory covering some 13,000

trees and 800 parks in the country was published in 1992 in the book ‘Arbres de Belgique/Bomen in België’, illustrated by Roel Jacobs (Baudouin & de Spoelberch 1992).

The publication of a book did not stop the work. Many trees and parks had not been visited or were only superficially screened. Each year new inventories are made and many new remarkable plants are being discovered. Even remarkable collections have been rediscovered, such as the Waalborrepark in Asse (Quintelier et al. 2001). D. Geerinck has since achieved a complete inventory of the Brussels Region (Geerinck et al. 1993-94). The old forestry arboreta, both in Flanders and Wallonia have been rediscovered and plans have been made to redirect the arboreta to more recreational and educational parks (Struelens 2001). The society is considering revisiting 100 of the most important parks and arboreta in the year 2002 to determine growth statistics for major exotic trees.

3.4 Dendrological advice

Members of the society regularly provide advice to both public and private gardens, providing the owners or managers with information on the trees, their identity, suggestions for maintenance and labelling of such collections.

3.5 The BELTREES database

Some 15,000 entries, gathered since 1987, have been entered in a computer database held by Ph. de Spoelberch. The data contain the individual ID number, the scientific name, an indication of the health status, girth measured at 1.5 metre, height (if known), date of measuring, the location within the park, the province, the city or municipality, various details, and the ranking within the taxa.

3.5.1 The statistics by region. By the summer of 2001, the database covered some 14,472 living trees. Of these, 13,284 (92 %) are in a reasonable condition. Some 614 trees were mentioned as particularly vigorous and healthy. On the contrary 219 trees (2 %) are in poor health or poorly adapted to the ecological conditions prevailing in Belgium. 857 trees (6 %) are clearly damaged, mostly by storms, 112 trees (1 %) were dying. The number of trees catalogued by park, by province and by region can be found in table 1.

Table 1. Number of catalogued trees and parks by province & region

Province & region	Number of trees		Number of parks	
Antwerpen	1,034	7.1%	47	5.2%
Limburg	825	5.7%	46	5.1%
Oost-Vlaanderen	1,182	8.2%	57	6.3%
Vlaams-Brabant	2,094	14.5%	83	9.2%
West-Vlaanderen	608	4.2%	40	4.4%
FLANDERS	5,743	39.7%	273	30.3%
Brabant wallon	467	3.2%	42	4.7%
Hainaut	1,400	9.7%	132	14.7%
Liège	2,070	14.3%	141	15.7%
Luxembourg	1,205	8.3%	43	4.8%
Namur	1,212	8.4%	136	15.1%
WALLONIA	6,354	43.9%	494	54.9%
BRUSSELS CAPITAL REGION	2,375	16.4%	133	14.8%
TOTAL	14,472		900	

3.5.2 Number of different species and cultivated varieties (taxa). The 14,472 trees belong to some 1,440 different taxa, of which 60 % are botanical species and 40 % hybrids or named cultivated varieties (cultivars). It is worth noting that more than 600 taxa are only represented by

one single plant: these are obviously species or cultivars, which are rare and rarely planted. 32 tree species, well known and each represented by more than 100 specimens, compose 39 % of the total number of plants. These are: *Abies nordmanniana*, *Acer platanoides*, *A. pseudoplatanus*, *A. p. 'Leopoldii'*, *A. saccharinum*, *Aesculus hippocastanum*, *Ailanthus altissima*, *Carpinus betulus*, *Castanea sativa*, *Fagus sylvatica*, *F. s. 'Pendula'* and *F. s. f. purpurea*, *Fraxinus excelsior*, *Ginkgo biloba*, *Juglans nigra*, *Liriodendron tulipifera*, *Picea abies*, *Pinus nigra*, *P. strobus*, *Platanus x hispanica*, *Pseudotsuga menziesii*, *Quercus robur*, *Q. rubra*, *Robinia pseudoacacia*, *Sequoiadendron giganteum*, *Taxodium distichum*, *Taxus baccata*, *Thuja plicata*, *Tilia cordata*, *T. platyphyllos*, *T. tomentosa* and *T. 'Petiolaris'*.

3.5.3 Champion trees. Champion trees have been defined very simply: these are single stemmed trees with the largest girth (measured at 1.50 metre). A characteristic sign appears in the appendix of the above mentioned book 'Arbres de Belgique/Bomen in België', which allows one to identify the ranking of each tree in the champion trees listing. Multi-stemmed trees, dying trees, or severely damaged trees have been excluded from this list. The four characteristic signs which allow identifying the top 20 trees in each taxon are: (**) for the biggest, (*) for the next three, (°) for the next six and (.) for the next ten. The symbol (–) is used to mention a remarkable tree which does not appear among the top 20 or is not taken into account because of a multi-stemmed or damaged status. Table 2 provides an overview of the number of champion trees and dendrological parks (with champion trees) by province and by region.

Table 2. Number of champion trees and parks by province & region

Province & region	Number of champion trees	Number of parks with champion trees
Antwerpen	135	26
Limburg	60	21
Oost-Vlaanderen	147	22
Vlaams-Brabant	223	39
West-Vlaanderen	29	17
FLANDERS	594	125
Hainaut	69	30
Liège	115	49
Luxembourg	106	18
Namur	43	29
Brabant wallon	18	11
WALLONIA	351	137
BRUSSELS CAPITAL REGION	108	43
TOTAL	1,053	305

3.5.4 The biggest trees: 6 metre in girth and above! (tables 3 and 4). Of the 14,472 trees catalogued, 175 were larger than 6 metre in girth. For obvious reasons, they are only found in the more common taxa, not necessarily indigenous: *Acer pseudoplatanus* (1), *A. p. f. purpureum* (1), *Aesculus hippocastanum* (1), *Castanea sativa* (12), *Cedrus libani* (8), *Fagus sylvatica* (12), *F. s. f. purpurea* (25), *Fraxinus excelsior* (1), *Liriodendron tulipifera* (4), *Pinus nigra* (1), *Platanus orientalis* (4), *P. x hispanica* (12), *Populus x canadensis* (4), *Quercus robur* (14), *Q. rubra* (1), *Robinia pseudoacacia* (1), *Salix alba* (3), *Sequoiadendron giganteum* (31), *Taxodium distichum* (3), *Thuja plicata* (1), *Tilia cordata* (6), *T. platyphyllos* (24), *T. tomentosa* (1), *T. x europaea* (3), *Ulmus laevis* (1). Again, one may wish to note that 45 of these were bigger than 7 metre in girth and 13 actually more than 8 metre in girth (table 4).

Table 3. Trees by girth (measured at 1.50 metre height)
(**): the biggest tree by taxon; (*): the three next; (°): the six next; (.): the ten next; (-): not a champion tree but remarkable or of particular interest

Girth	Number of trees	Number of trees by category					
		(**)	(*)	(°)	(.)	(-)	Other
>7 m	45	10	9	1	0	25	0
6-7 m	130	12	25	29	18	46	0
5-6 m	503	20	32	44	61	92	254
4-5 m	1,346	56	86	86	123	137	858
3-4 m	2,633	94	158	207	256	148	1,770
2-3 m	3,648	170	297	366	360	198	2,257
1-2 m	3,676	303	428	504	508	229	1,704
< 1 m	2,491	388	483	361	229	217	813
Total	14,472	1,053	1,518	1,598	1,555	1,092	7,656

Table 4. Trees with a girth > 8 metre

Ranking	Taxon	Girth	Year	Location
–	<i>Platanus x hispanica</i>	9.99	1995	Municipal park De Kwabeek, Boutersem, Vlaams Brabant
**	<i>Quercus robur</i>	9.85	1985	Church of Liernu, Eghezée, Namur
–	<i>Platanus x hispanica</i>	9.40	1987	Castle of Saulchoy, Soignies, Hainaut
–	<i>Tilia cordata</i>	9.05	1986	Church of Arc-Ainières, Frasnes-Lez-Anvaing, Ath, Hainaut
–	<i>Tilia platyphyllos</i>	9.00	1990	Park Vordenstein, Schoten, Antwerpen
**	<i>Tilia platyphyllos</i>	8.75	1989	Lime tree of Conjoux, Ciney, Namur
–	<i>Fagus sylvatica</i>	8.58	1988	'Crawe Hesse', Houffalize, Luxembourg
**	<i>Populus x canadensis</i> 'Marilandica'	8.50	1989	Abbey park, Geraardsbergen, Oost-Vlaanderen
–	<i>Cedrus libani</i>	8.47	1990	Ommerstein, Dilsen, Limburg
**	<i>Castanea sativa</i>	8.45	1989	Schoubroek Castle, Lovendegem, Oost-Vlaanderen
**	<i>Tilia x europaea</i>	8.36	1987	Castle of Doyon, Havelange, Namur
**	<i>Sequoiadendron giganteum</i>	8.20	1994	Closerie du Rond Chêne, Esneux, Liège
–	<i>Fagus sylvatica</i>	8.10	1989	Closerie du Rond Chêne, Esneux, Liège

‘***’: single stemmed tree with girth at 1.5 m; ‘–’: girth measured lower down due to forking or large branche(s) at 1.5 m.

3.5.5 Purpose and use of the BELTREES database.

- *Historical*: the list of trees gives a good indication of those plants that were fashionable at certain times in the past; although we seldom have data on the date of planting, size is a sufficiently good approximation to determine the fashionable varieties and their possible introduction to cultivation.
- *Detailed location*: the database identifies which parks and which regions harbour particular species or champion trees.
- *Age of the trees*: by comparing and extrapolating data for specimen of similar taxa, it is quite possible to reach effective estimation of the average growth and therefore of the age of the plantings.
- *Hardiness*: by comparing the presence or absence of certain taxa in various regions of the country, one can assess the hardiness of these within the country.
- *Regional frequency*: the database also provides the reader with information about the frequency of some plants in various regions, city or country and soil types.

- *Taxonomy and nomenclature*: a catalogue such as this allows to point out approximate or erroneous identifications. It also allows all garden owners to have an updated and corrected taxonomic list of the trees, identified in their parks.
- *Conservation*: the inventory and cataloguing has provided the rediscovery of rare ancient cultivars which were once in the nursery trade and which deserve to be repropagated.

4 Publications

4.1 Books and folders

The activities of the society and its members have resulted in some valuable publications available to the general public. The publication of the dendrological inventory of trees in Belgium (Baudouin & de Spoelberch 1992) has been a milestone in Belgian dendrology: discussion of growth and occurrence in Belgium of important tree species, exhaustive lists with measurements of trees by species and parks, overall illustrated with splendid colour photographs of individual trees make this book an indispensable tool for Belgian dendrologists and park managers.

Active members or the society itself contribute regularly to various dendrological publications: the inventory of remarkable trees in Brussels (Geerinck *et al.* 1993-94) and leaflets [about the botanical garden of Brussels ('Jardin botanique', 'Kruidtuin'; Dupont & Degembe 1993) and about the Robert Lenoir Arboretum (Anon. 1994)].

4.2 Yearbook

The yearbook presents the summary of all of the activities of the society during the past year. It contains a number of articles such as description of parks, discussions concerning trees or various collections and all of the papers presented during the workshop. In addition, a tour report for the study tour and the daily excursions are provided. In the chapter 'dendrological notes' several members present their personal observations in their own collection. Obviously, the yearbook intends to remind all members of the activities of the past year, but in the long run, it should allow establishing a significant historical reference base. This will provide invaluable information in the future. Finally, the yearbook is the main contact of the society with the outside world.

4.3 Newsletter

A quarterly newsletter informs members with general information, the programme of activities, various contacts, dendrological news and a review of recent publications.

Acknowledgements. – The author wishes to express his gratitude to LMr. Ph. de Spoelberch for providing a copy of the Beltree database in order to realise the analysis of the tree inventory and also for his invaluable help, together with Mr. Roel Jacobs, in reviewing and translating the original text in English.

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Other societies and working groups

Vlaamse Mycologische Vereniging VMV

Paul Van der Veken

V.M.V. Nationale Plantentuin van België, Domein van Bouchout, B-1860 Meise, Belgium

Andre.Dekesel@br.fgov.be

Gestart in 1991 als overlegcomité van Vlaamse Mycologische Verenigingen om de samenwerking te bevorderen en de mycologie in Vlaanderen te promoten. Vanaf 1996 omgevormd tot de VZW Vlaamse-Mycologen-Vereniging.

Zetel: Nationale Plantentuin van België, Domein van Bouchout, B-1860 Meise.

Voorzitter: Emer. Prof. P. Van der Veken (09/222 93 24).

Secretaris: Dr. A. De Kesel (02/260 09 38 ; andre.dekesel@br.fgov.be).

De activiteiten zijn gericht op het verstevigen van de banden tussen de lokale mycologische verenigingen: jaarlijks symposium (Mycologendag), vijf gemeenschappelijke excursies en een paddestoelenkijkdag (in oktober) voor een ruimer publiek. Soms wordt aandacht gevraagd voor een speciaal thema, zoals in 2001 studie en inventarisatie van de fungi in eigen tuin.

Publicaties: Mededelingen gehouden op de Vlaamse-Mycologen-Dagen (1992-1995) ; nadien V.M.V.-JAARBOEK (1997-heden) [sinds 2003 ook een driemaandelijks VMV-Nieuwsbrief, per post of per e-mail, met diverse vaste rubrieken en een uitgebreide activiteitenkalender van de meeste mycologische excursies in Vlaanderen].

Lidmaatschap: toegankelijk voor leden van lokale, erkende mycologische verenigingen; lidgeld 6,20 euro op 000-1732330-07 van de Vlaamse-Mycologen-Vereniging vzw, Domein van Bouchout, B-1860 Meise. Te betalen vóór 1 maart. Het Jaarboek is inbegrepen in het lidgeld.

Oost-Vlaamse Mycologische Werkgroep (OVMW)

Contact: prof. dr Mieke Verbeken, K.L.Ledeganckstraat 35, B-9000 Gent, Belgium; mieke.verbeken@UGent.be

Opgericht in 1982, telt deze feitelijke vereniging nu een 30-tal werkende leden, voornamelijk uit Oost- en West-Vlaanderen. De vereniging zetelt in de onderzoeksgroep Mycologie, Vakgroep Biologie, Universiteit Gent en is vertegenwoordigd in de Vlaamse Mycologen-Vereniging (VMV).

De belangrijkste activiteit van de OVMW bestaat uit bijdragen tot de taxonomische en chorologische kennis van de macrofungi in Vlaanderen. Dit gebeurt via een 20-tal excursies (meestal gevolgd door determinatiesessies), vier wintervergaderingen en hulp bij het organiseren van een paddestoelententoonstelling in de Plantentuin van Gent. Door deze activiteiten wordt aan de leden de mogelijkheid geboden gezamenlijk te determineren en te discussiëren en op de hoogte te blijven van de recente literatuur. Naast het opstellen van excursielijsten per gebied, wordt ook herbariummateriaal bijgehouden van kritische of zeldzame soorten (gedeponeerd in of voorbestemd voor GENT). Bijzondere aandacht wordt besteed aan o.a. Aphyllophorales, Leotiales (Ascomycota), Russulales, Mycena (Agaricales) en Myxomycota. Verscheidene leden documenteren uitvoerig bijzondere vondsten via beschrijvingen, microscopische tekeningen, aquarellen of foto's. De interesse van deze werkgroep blijft uiteraard niet beperkt tot het Vlaamse landdeel: sporadisch worden ook excursies in andere gebieden georganiseerd.

G. Rappé, K. Busschots & E. Robbrecht (eds.) *BBB 2001. Botanical biodiversity and the Belgian expertise*. Proceedings of a symposium held in October 2001 at the National Botanic Garden of Belgium. ISBN 90-72619-54-4

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Studiegroep Europese en Mediterrane Orchideeën (SEMO) – Vlaanderen

Contacten: René Meeuwis, Steenweg op Wezemaal 141, B-3110 Rotselaar, Belgium; semo@pi.be;
Walter Van den Bussche, Heihoekstraat 188, B-9100 Nieuwkerken-Waas, Belgium; walter.vdbussche@pi.be

SEMO Vlaanderen werd opgericht in 1989 en heeft volgende doelstellingen: studie van Europese en mediterrane orchideeën in het algemeen; actief natuurbeheer ter bescherming van bepaalde kwetsbare en orchideeënrijke vegetaties; uitwerken van beheersadviezen (op verzoek); onderzoek naar populatie-dynamiek; verspreidingsonderzoek in Vlaanderen; organisatie van prospectietochten, excursies en weekends; lezingen en voordrachten met dia's; jaarlijks publicatie van het tijdschrift 'Liparis' (sinds 1995), met extra uitgave in 2000.

Vlaamse Werkgroep Bryologie en Lichenologie, sinds 1988

Contacten : Serge Hoste, Gaversesteenweg 579, B-9820 Merelbeke, Belgium;
Geert Raeymaekers, Kroonlaan 272, B-1050 Brussel, Belgium

Doelstellingen: studie van mossen en korstmossen; behoud van mossen en korstmossen en hun habitat.

Studiegebied: vooral Laag- en Midden-België.

Activiteiten: jaarlijks een zestal excursies; jaarlijks een weekend; jaarlijks een themadag met determinatie; permanente opvolging van aandachtsoorten; jaarlijks publicatie van 'Muscillanea' (sinds 1981).



Terrestrial vegetation patterns and plant communities on Pacific coral cays

Jacques R. De Sloover

Unité d'Écologie et de Biogéographie, Université Catholique de Louvain,
4-5 Place Croix du Sud, B-1348 Louvain-la-Neuve, Belgium

Abstract. – *Domm's model (1971) about the physiognomic vegetation units distribution on Pacific coral cays has been improved. This improvement was needed in view of the many geomorphogenetic or biotic factors involved in the modelling of these cays and of their vegetation units mosaics. Seventeen plant communities are briefly described and linked together: the open fore-dune pioneering community, herbfields or savannas on consolidated inland sands (possibly on seabird islands but on coral shingle levees too), the littoral beach crest scrub, the inland scrub on sand or coral rubble, climacic forests (the *Pisonia grandis* woodland on lightly acid humic soils, the *Terminalia catappa* rainforest, the Manilkara kauki monsoon forest), the samphires communities, the windsheared *Pemphis* scrub and four mangroves communities (the *Osbornia*, the *Lumnitzera*, the *Aegialitis* and the *Rhizophora* mangroves).*

Samenvatting. – **Terrestrische vegetatiepatronen en plantengemeenschappen van Pacifische koraaleilanden.** *Domm's model (1971) betreffende de verspreiding van de fysionomische vegetatie-eenheden op Pacifische koraaleilanden werd verbeterd. De aanpassing was nodig vanuit de optiek van de vele geomorfogenetische of biotische factoren die betrokken zijn in de vorming van deze eilanden en van hun mozaiekvegetaties. Zeventien plantengemeenschappen worden kort beschreven en onderling verbonden: de pioniersvegetatie van het open voorduin, kruidvegetaties of savannas op geconsolideerd 'binnenlands' zand (mogelijks op zeevogeleilanden, maar ook op koraalgrint), de kustgebonden strandkamstruweel, 'binnenlands' struweel op zand of koraaldebris, climaxwouden (*Pisonia grandis* bos op licht zure, humeuze bodems, *Terminalia catappa* regenwoud, *Manilkara kauki* moessonwoud), schorrevegetaties, stuifwaterstruweel met *Pemphis* en vier mangrovegemeenschappen (respectievelijk *Osbornia*, *Lumnitzera*, *Aegialitis* en *Rhizophora* mangrove). Vertaald door de redactie.*

Résumé. – **Mosaïques de végétations terrestres et communautés végétales sur les îles coralliennes du Pacifique.** *Le modèle de Domm (1971) relatif à la distribution des unités physionomiques de végétation sur les îles coralliennes du Pacifique est amendé. Cette adaptation du modèle était nécessaire de façon à tenir compte de l'ensemble des facteurs géomorphologiques et biotiques contribuant à façonner les cayes ainsi que la mosaïque des unités de végétation qui les couvrent. Dix-sept phytocénoses sont ensuite brièvement décrites et rangées dans six unités supérieures : pelouse préduinaire ouverte, herbages (ou savanes) sur sables intérieurs stabilisés éventuellement soumis aux influences des oiseaux marins nicheurs mais aussi sur levées de galets*

coralliens, fourré littoral, fourré interne sur sable ou sur débris coralliens, forêts climaciques (forêt à Pisonia grandis sur sable humique acidocline, forêt pluvieuse à Terminalia catappa, forêt de mousson à Manilkara kauki), phytocénoses des prés salés, fourré aérohalin de Pemphis ainsi que quatre types de mangroves (mangrove à Osbornia, à Lumnizera, à Aegialitis et à Rhizophora).

Abbreviations: GBR, Great Barrier Reef; PNG, Papua New Guinea

1 Introduction

Still today our knowledge of coral cay vegetation is hindered by “the widely held, but erroneous, idea that it is very much alike everywhere and therefore not much worth studying” (Fosberg 1976). In fact the assumption has been made that since coral islands vegetation is poor and apparently monotonous, generalized descriptions will fit any island equally well. Now we do lack detailed vegetation descriptions and the few ones that are available prove to be inadequate to sketch a general account of coral cay vegetation.

The fact that, at least in some sectors such as Bismarck Sea (PNG), the vegetation of most coral islands has been since a long time replaced by coconut plantations, by tourism resorts or are deeply altered by feral animals makes the reconstruction of the original vegetation difficult, even on a generalized level.

During the early seventies a graphical model accounting for the vegetation pattern on coral cays of the Capricorn Group, Australia, was devised by Domm (1971: fig. 2, p.14). In accordance to this model the physiognomic units of vegetation on these cays are laid out in a concentric way above the upper high tides limit. From that tidal mark inside and beyond the strand is a first belt of pioneering open herbfield: this outside surrounding area stretches out more or less widely according to, among other things, the steepness of the strand and is made up of salt tolerant grasses and/or herbs which mostly derive from sea dispersed seeds. Then, moving further inside, that first belt changes progressively or abruptly in a scrub belt with shrubs and/or light demanding small trees. Finally the central area of the cay is wooded with large trees forming a more or less closed canopy (fig. 1).

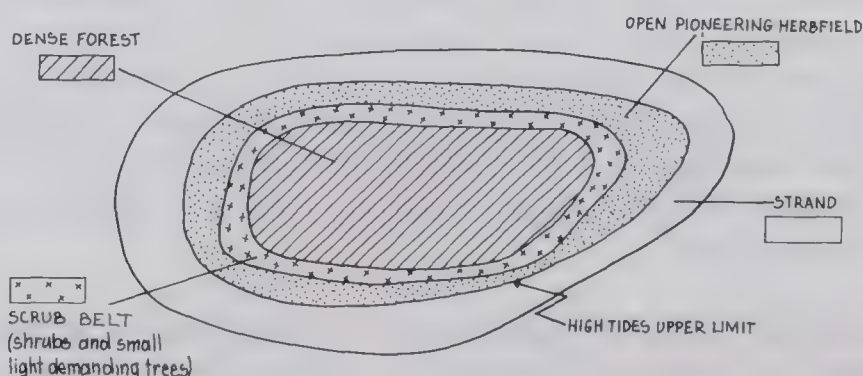


Figure 1. Domm's model of the vegetation zones on the Capricorn group (GBR) sandy coral cays (adapted from Domm 1971).

1.1 A dynamic model and its requirements

Such a static model can still be improved by superposition of a dynamic system to the former, in order to round it off to a succession model. This last one was not explicitly detailed by Domm (1971) as it accounts for the genesis, the setting up and the development of the vegetation units.

This model could be described as follows: on bare sands and coral rubble piles that build up and emerge at definite spots on platform reefs, woody species plantlets set up early among pioneering grasses or herbs and, like these, are reaching the cay as seadrifters. These intruders foretell the next step i.e. the scrubby vegetation which ends in overrunning the pioneering grasses and herbs. Endly tall trees that are mainly brought along by birds set up under the shrubs and would conclude the succession with a closed forest (fig. 2).

Nevertheless the value of that dynamic model is only growing when the following three conditions are fulfilled: (1) the cay is still in an active aggradation stage i.e. when reef dynamics continuously bring along detritic material contributing towards cay's spreading; in fact when material supplies are dropping and thus once cay spreading has been stopped, vegetation dynamics carry on evenly well and the herbfield is overgrown by the vegetation units that inexorably follow, (2) current climatic conditions allow the above described succession and particularly the final woody stage, (3) biotic agents like seabirds or turtles do not hold up or hamper the succession or anthropic impacts, e.g. even the most unobtrusive fellings, do not compete with the final step. These three requirements are far from being fulfilled everywhere. Furthermore, the age of the cays and their geomorphological developments also influence the setting up of the vegetation units: the latter conditions, which are somewhat correlated, are basic to understand the arrangement of the plant communities, particularly on the oldest cays.

Domm's model had thus to be amended or improved to explain the encountered vegetation layouts.

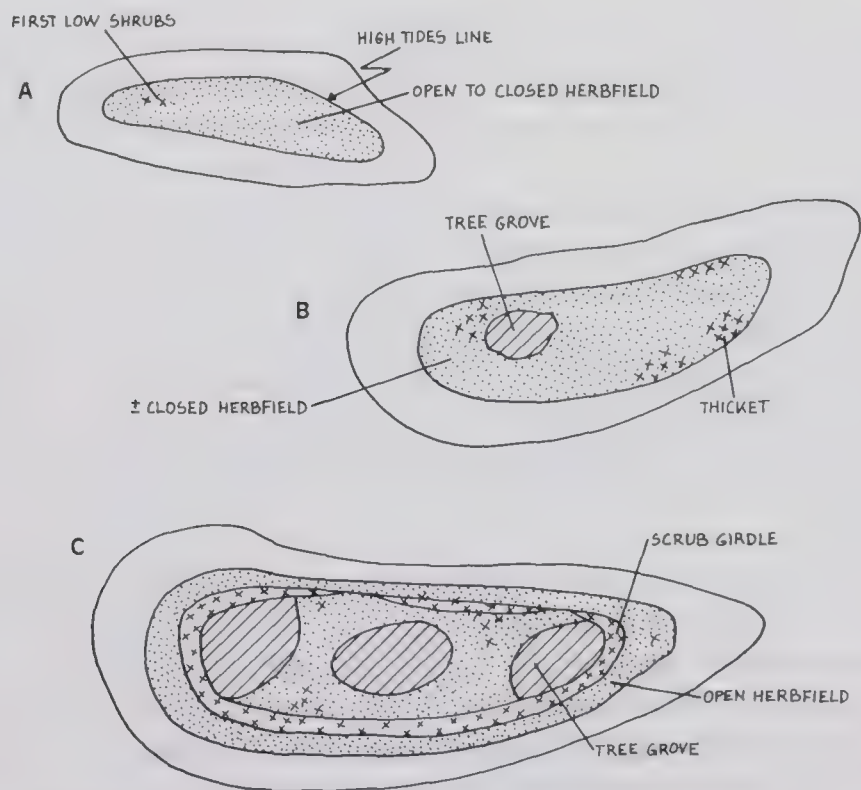


Figure 2. Idealised vegetation succession model on sandy cays from the early colonization stages by seadrifted species (A) to the subterminal stages (C).

1.2 The established vegetation data

Classic textbooks either give a rather brief account on the vegetation of coral cays (Beadle 1981), or do not even mention it (Groves 1981). At best they merely present lists of some selected species in a number of ill-defined physiognomic vegetation units like strand or mat plants, herbflats species, ring of shrubs, low forests or mixed rainforest (Beadle 1981, p.615). In spite of some

ecological indications like density of cover or trends in zonation or succession, links between the accepted units are completely lacking.

In his first attempt to identify the physiognomic units of vegetation and to get some idea of their relationships Fosberg (1976) gave merely a list of the fifteen natural terrestrial 'communities' he recognized. These are easily identified by sight on the basis of the dominant or codominant species. For the northern section of the GBR, Stoddart & Fosberg (1991) provide a simple empirical classification and description of twelve main physiognomic vegetation types. Among other things, progressive colonisation following beach aggradation is suggested for the first time, as are the patchy herbaceous communities on seabird islands. Frequency of each species in each vegetation unit is still lacking however.

Monographs on single cays like One-Tree Is. (Heathwole & al. 1981) are again most of the time simply descriptive, giving above all lists of plants and comments on the relevant ones; sometimes structural notes about the recognized vegetation units are also provided.

Furthermore a number of casual descriptions of physiognomic units on coral cays have been made when looking for the habitat of seabirds, their population numbers and their fluctuations. Numerous such short accounts have been published in the reports entitled 'Seabirds Islands' (cf. relevant periodicals like *Corella* from n°1- 1977 or *Emu*).

2 Investigated area

Our investigations have been mainly carried out on coral cays off the north coast of PNG (Laing Is. and the five surrounding cays), on cays of the northern section of the GBR (Qld., Australia) west of Lizard Is. (namely Eagle Islet), on Green Is. and Michaelmas cay (off the Cairns area.) and on islands of the Capricorn group at the southern end of the GBR (namely Heron Is. and some of the nearby other cays like Wilson Is., Erskine Is. and Masthead Is.). Discrete sand cays of low wooded islands like Nymph Is., the five cays of the Turtle group and Low Isles have been included too. Data used for comparisons were also gained from the relevant literature.

Even if they all are sea level cays they don't fall within the same geomorphological category. According to Stoddart & al. (1978) they are to be listed in one of the following three categories: elongate and narrow vegetated sand cays (like Combe Is., Eagle Is. and Michaelmas Cay), large oval vegetated sand cays (like Green or Masthead Is.) and low wooded islands (like Nymph, Low Isles or Turtell Is.). For our purpose, this distinction is significant as it is based not only on the age of the cays and on the nature and distribution of sediments but also on some criteria derived from vegetation.

Coral cays lie within a substantial diversity of precipitation values and distribution i.e. from an estimated 600 mm to possibly 6000 mm. In the margin of that wide range intertropical ecosystems are thus submitted to varying climates, from very dry to perhumid ones.

Transects and phytosociological relevés were made everywhere but mostly on some of the following cays: Laing, Heron, Eagle, Nymph and Turtle V Is.; in some cases (Laing Is., Eagle Islet, Nymph Is.) soil samples were taken for further analyses in the lab.

3 Results

The pieces of information that were collected have been summarized in order to provide a general picture, erasing the poorly significant analytical data and linking, as far as possible, the recognized vegetation units to each other. Our viewpoint aimed at emphasising the common features of all cays rather than underlining their apparent uncommon nature. This approach differs fundamentally from that of Fosberg (1976).

The first section aims at illustrating as well the above physiognomic dynamic model as the cases apparently derived from it. The second section will attempt to briefly characterize the main plant communities, leading to the climatic woodland in the succession stages, their diversity and distribution.

3.1 The physiognomic approach

3.1.1 Testing the model. Searching for published vegetation layouts of investigated cays providing typical examples of Domm's model we failed. Nevertheless a few reports on vegetation pattern at first sight seem to match the model. That is how the following two cases seemed the most appropriate to our request.

Combe Island (Howick Group) is a small 4.0 ha cay near Cape Melville (14°25' S, 144° 55' E). At first glance its vegetation pattern perfectly fits the model featuring concentric belts of vegetation (King et al. 1985): (a) an outer zone with sand binders, (b) a belt of open herbfield with tufted grasses, (c) an inner closed grass/herbfield and (4), in the central area, a low 2-3 m high vine thicket (fig.3A). The most advanced central vegetation unit in the succession is still at the scrub stage and could stay like that for a long time. Yet the final forest stage is lacking. If human impact does not seem to be involved, climatic dryness or seabird pressure look like possible causes of the lacking forest as will be suggested hereafter.

The vegetation of Masthead Is. (Capricorn Group) was described by Cribb (1975). The author recognized the three concentric vegetation belts of the model: in the central zone a predominant cover of *Pisonia* forest surrounded by a narrow belt of coastal scrub, the latter edged by a grass and herb belt.

These two examples were selected as they are among the closest descriptions to the model we could find. Additional examples could be quoted but they would all show that cays matching the model perfectly are virtually impossible to find.

3.1.2 Climax vegetation. When approaching a number of cays by air or by sea, either off the northern coast of PNG, either around Heron Is. at the southern end of the GBR, at first sight they look entirely forest-covered up to the upper strand line. After landing that impression is often strengthened, though in some cases a narrow strip of grasses and herbs can be observed on the outer fringe of the woodland. Frequently forest trees are leaning over the upper strand and there is no belt of shrubs or small trees lining the forest edge. At that point aggradation of the cay has been stopped for some time and succession does lead to the complete cover of the cay by a woodland; of course this forest is edged with sunloving woody species building the so-called mantel, like the edge of any forest patch. That structural layout (fig.3B) accounts for the potential vegetation of the cay as is described for Laing Is. (PNG), as an example (De Sloover 1992).

3.1.3 Senescent cays. From this point or sometimes decidedly earlier, declining processes come into play: storms or hurricanes sometimes sweep aside the whole cay or devastate sections of it. Man may drastically intervene with his clearings, plantations, guano mining or mass tourism. Most of these damages are however transient and one day the altered zone is anew given over to the succession processes (fig. 3C).

The opened gaps are progressively closed by reinstating the succession leading to the natural potential vegetation or more frequently to a paraclimax. For instance, on Laing Is. (PNG) every notch that has been cut of the forest mantel where a disused track took inside from the lagoon, is invaded by pioneering plants from the upper strand; from this early stage the succession starts off again (De Sloover 1992).

In other circumstances wide glades opened by hurricanes in the central forest or/and in the scrub belt develop into a vine thicket or in an open woodland: this kind of vegetation can keep up for a long time and form a so-called paraclimax. This was clearly established on Hoskyn larger cay

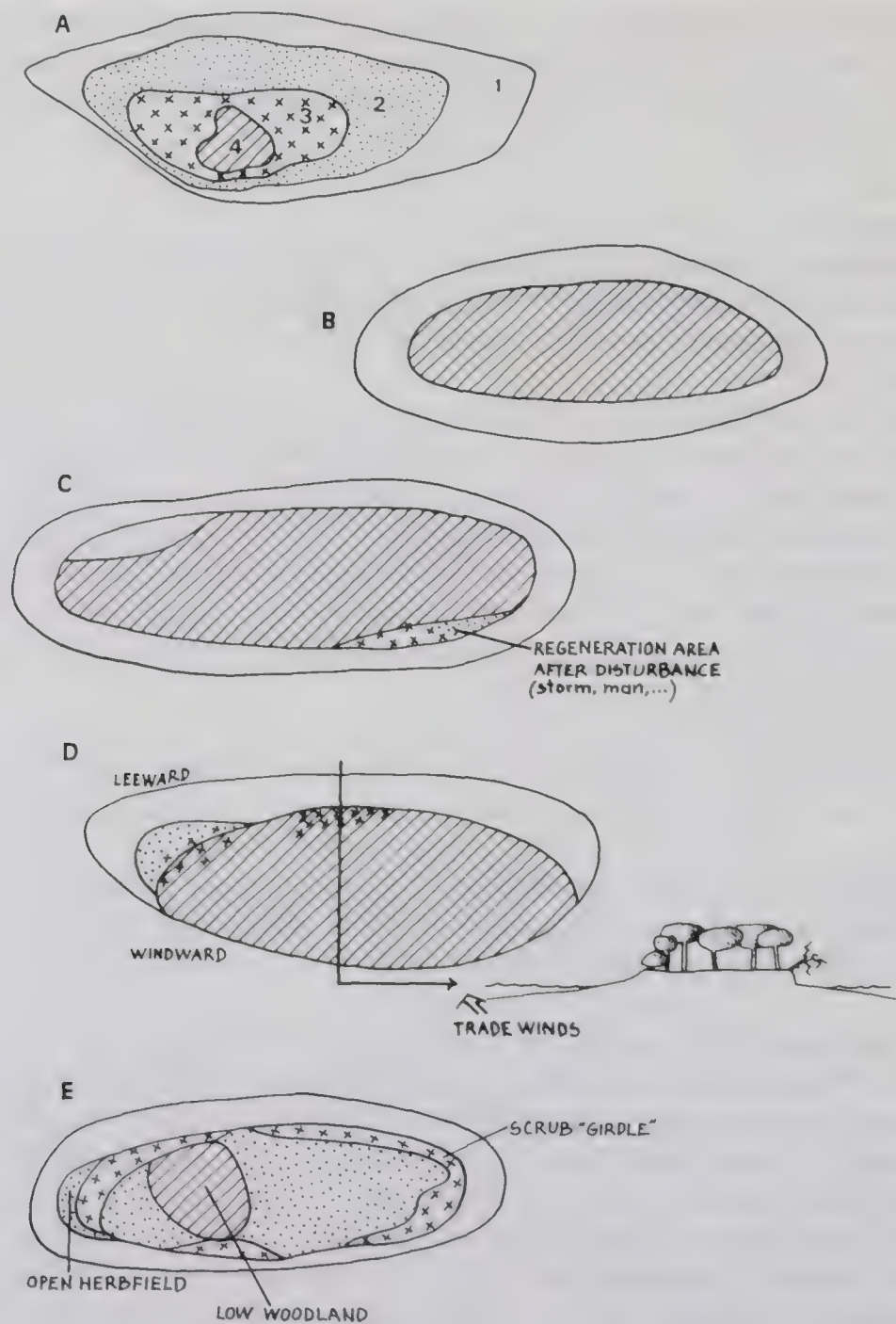


Figure 3. A: map of Combe Island with 4 vegetation zones: sand binders (1), grass and sand binders (2), grass/herb field (3), shrub/vine thicket (4) (after King & al. 1985); B-E: Plan view of idealised vegetation zones on sandy cays under discontinued aggradation (B), on senescent sandy cays (C), on attrition submitted sandy cays (D), on seabird sandy cays.

by Cribb (1972). Here two large areas are deviating from the model: for half the length of the cay the central forest is replaced by an apparent fairly stable glade occupied by shrubs, scramblers and vines and for the southern half the outer grass belt is lacking while shrubs and trees of the inner vegetation belts have collapsed onto the beach. The same was depicted from Heron Is. where the hurricane built up glade after thirty years was still replaced by a wide open *Pandanus* woodland (Fosberg 1961 and pers.obs. 1990).

3.1.4 Destructive processes. A quite different vegetation pattern appears when a coral cay area stops spreading and the strand on one side starts to become eroded: this possibly occurs under the joint effects of prevailing winds and water currents which can be modified around the islet. Often

the dragged away material from the windward shore is deposited in the lee which grows consequently. The damaged shore builds up a retreating embankment that gradually encroaches upon the vegetation on that side. Accordingly the vegetation pattern of the cay is turning asymmetrical: plant scraps are lying on the windward strand while leewards a gentle wide upper strand takes in the hereabove described pioneering herbfield (fig. 3D). In this way the cay is slowly moving onto the reef and ultimately can disappear being broken up on the leeward reef slope. Such processes are quite obvious on Eagle Is. (De Sloover & Liégeois 1997) or Masthead Is. (pers. obs.); they are less spectacular on the very low cay of Laing Is. (PNG) where the windward vegetation mantle is made up with quite different shrubs and trees than the one leewards (De Sloover 1992). That contrasting floristical and phytosociological composition thus expresses more differentiated environments than could appear at first sight.

3.1.5 Seabird cays. Seabird cays very often show a patchy vegetation pattern that is far from following the above basic model. The upper strand as usual supports the open strandline plant assemblage with *Sesuvium portulacastrum* while the rest of the cay is covered by a mixed grass and herb flat possibly broken by individuals, small patches or clumps of shrubs and small trees like *Argusia argentea*, *Clerodendron inerme*, *Premna serratifolia* festooned by the vine *Ipomoea macrantha*. This generalized description fits equally well most of the seabird cays of the GBR like Raine Is. (King 1986), Pelican Is. (King & al. 1985), Stainer Is. (King 1985a), Stapelton Is. (King 1985b), Michaelmas Cay (King 1985c), Frigate Cay (Walker & Jones 1986a), Price Cay (Walker & Jones 1986b), Bell Cay (Walker & Jones 1986c) and less typical others.

Control of the vegetation by seabirds like terns, noddies, boobies or gulls is a complex process involving mechanical impacts as well as chemical ones. Heavy occupation by thousands of nesting seabirds, even for a few summer months, completely alters plant cover, composition and succession: at best the plant cover remains at the herbfield stage with a few stunted woody species like *Abutilon indicum* or *Argusia argentea*. The number of plants is reduced and it includes a few phosphatetolerant species. On the cays where nesting colonies are not so densely stocked (< 500 to 1000 birds) the less drastic impact is correlated with the ethology of the implied birds. The crowded crested tern crèches set up in open grass/herb swards while the little tern settles on open sandy slopes: on the same cay they are mutually exclusive in space and time, like on Eagle Is (Liégeois & De Sloover, in prep.); even so the plant cover sustains their presence: when landing on the cay the vegetation pattern looks to match Domm's model but when going through the scrub belt where bare slope corridors have been managed by birds, the standard sequence is interrupted. In other words, the central woodland is skipped and replaced by an extensive herbfield whose component species are similar to the ones from the upper strand belt and adapted to cope with the cations high content of soil engendered by seabird droppings (fig. 3E). Some limited areas that from time immemorial have been spared by schools of birds are taken up by groves looking like an impoverished forest that never could set up (De Sloover & Liégeois 1997).

3.2 The phytosociological approach

The above interpretation of the apparent physiognomic vegetation diversity that has been up till now recorded on the Pacific sandy coral cays carries to a unity of views that has never been gained previously when the stress was put on diversity amid floristic poverty. It stands in contrast with Fosberg's view stressing the diversity with grasses, scrubs or trees pure stands like *Neisosperma* forest, *Scaevola* scrub, *Suriana* scrub, *Guettarda* scrub forest, *Lepturus* meadow...each 'clonal' species of this impoverished flora imposing its own vegetation type. Hereafter we put forward another outlook so that the major vegetation units are based on as many criteria (physiognomic, ecologic and floristic) as possible. The seventeen recognized plant communities are here referred to the following six comprehensive phytosociological units. Results of a multilateral comparison of 270 vegetation relevés are collated in table 1 where presence index (roman numerals I to V

expressing the five classes of percentages by 20% steps) and the cover index (arab numerals) for the shown number of relevés are given. The degree of fidelity of each species to each plant community emerges from table 1 too. We refrained here from crediting each plant community with a formalized latin name as usually is done in the sigmatist system (Zurich-Montpellier method).

3.2.1 The upper strand grass and/or herb belt on sand cays. On new blown sand that piles up beyond the upper strand on spreading cays aswell as on new born ones, vascular plant seeds drifted by the sea germinate and start on an open foredune herbfield. A grass like *Thuarea involuta*, creepers like *Ipomoea pes-caprae* and herbs like *Euphorbia atoto* are the major settlers (table 1, col.1). They form a largely distributed community all over the Pacific. Beside those widely represented species other ones can be fairly well represented depending on the latitude: so on the southern end cays of the GBR *Cakile edentula* locally joins the previous wider distributed species.

Table 1. Presence index (roman numerals) and cover index (arab numerals) related to some indicative species for each ecological group of 17 vegetation units recognized on Pacific coral islands (sh: shrub, T: tree).

N° of column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Vegetation units	Upper strand herb field	Lepturus grassland	Savanna on sandy bird cays	Savanna on shingle levees	Sandy beach crest scrub	Central scrub on sand cays	Manilkara forest	Terminalia rainforest	Pisonia woodland	Sesuvium mats	Sporobolus swards	Samphire	Pemphis scrub	Osbornia mangal	Lumnitzera mangal	Aegialitis mangrove	Rhizophora mangrove
Number of relevés	29	10	54	17	43	11	15	4	12	4	6	15	9	5	5	17	14
Ipomoea pes-caprae	IV410	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thuarea involuta	III125	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euphorbia atoto	II 14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lepturus repens	.	V775	III 282	IV350	.	.	.	.	.	.	.	.	.	.	.	.	.
Euphorbia tannensis	.	V 20	III 26	III 6	.	.	.	.	.	.	.	.	.	.	.	.	.
Cleome viscosa	.	V 16	II 1	III 10	.	.	.	.	.	.	.	.	.	.	.	.	.
Wedelia biflora	.	III 38	I 27	I +	.	.	.	.	.	.	.	.	.	.	.	.	.
Boerhavia glabrata	.	.	IV 95	III 23	.	.	.	.	.	.	.	.	.	.	.	.	.
Canavalia maritima	.	.	IV 11	V204	.	.	.	.	.	.	.	.	.	.	.	.	.
Ipomoea macrantha	.	.	.	III 123	I 13	.	.	.	.	.	.	.	.	.	.	.	.
Capparis lucida	.	.	I +	III 47	.	.	.	.	.	.	.	.	.	.	.	.	.
Myoporum acuminatum	.	.	.	III 54	I 86	.	.	.	.	.	.	.	.	.	.	.	.
Scaevola sericea (sh)	.	.	.	.	III 213	.	.	.	.	.	.	.	.	.	.	.	.
Argusia argentea (sh)	.	.	.	.	III235	.	.	.	.	.	.	.	.	.	.	.	.
Cordia subcordata (sh)	.	.	.	.	III122	.	.	.	.	.	.	.	.	.	.	.	.
Derris trifoliata (sh)	.	.	.	.	II 36	.	.	.	.	.	.	.	.	.	.	.	.
Aglaia elaeagnoides (sh)	.	.	.	.	.	V148	III 92	.	.	.	.	.	.	.	.	.	.
Eugenia reinwardtiana (sh)	.	.	.	.	.	V 64	.	.	.	.	.	.	.	.	.	.	.
Diospyros maritima (sh)	.	.	.	.	.	V128	IV57	.	.	.	.	.	.	.	.	.	.
Diospyros compacta (sh)	.	.	.	.	.	IV198	I 16	.	.	.	.	.	.	.	.	.	.
Planchonella obovata (sh)	.	.	.	.	.	IV112	.	.	.	.	.	.	.	.	.	.	.
Manilkara kauki (T)	.	.	.	.	.	.	V580	.	.	.	.	.	.	.	.	.	.
Terminalia muelleri (T)	.	.	.	.	.	.	II 47	.	.	.	.	.	.	.	.	.	.

Drypetes lasiogyna (sh)	.	.	.	I +	.	.	IV 10	.	.	.	.	.	.	.	.	.	.
Glycosmis pentaphylla (sh)	.	.	.	.	.	.	IV 37	.	.	.	.	.	.	.	.	.	.
Terminalia catappa (T)	.	.	.	.	.	.		V438	.	.	.	.	.	.	.	.	.
Neisosperma oppositifolia	.	.	.	.	.	.		V 8	.	.	.	.	.	.	.	.	.
Terminalia microcarpa (T)	.	.	.	.	.	.		III 6	.	.	.	.	.	.	.	.	.
Myristica schleinitzii (T)	.	.	.	.	.	.		III 75	.	.	.	.	.	.	.	.	.
Pisonia grandis (T)	.	.	.	.	.	.			V833	.	.	.	.	.	.	.	.
Celtis paniculata (T)	.	.	.	.	.	.			III 19	.	.	.	.	.	.	.	.
Ficus opposita (sh)	.	.	.	.	.	.			III 55	.	.	.	.	.	.	.	.
Sesuvium portulacastrum	.	.	.	.	.	.				V650	V 30	V223	.	I 51	I 5	.	.
Salsola kali	III 8	.	.	.	.	.				IV 72	.	.	.	.	.	.	.
Sporobolus virginicus	.	.	.	.	.	.			II 38	V834	I 27	.	.	.	I 4	.	.
Sarcocornia quinqueflora	.	.	.	.	.	.				IV 38	IV347	.	I 75	.	.	.	.
Suaeda australis	.	.	.	.	.	.				III 54	V321	.	II 5	.	.	.	.
Pemphis acidula (sh)	.	.	.	I +	.	.						V614	.	.	.	.	.
Cynanchum carnosum	.	.	.	.	.	.						III 25	.	.	.	.	.
Osbornia octodonta (sh)	.	.	.	.	.	.							V485	I +	I 3	I 5	.
Batis argillicola	.	.	.	.	.	.							III 54	.	.	.	.
Lumnitzera racemosa (T)	.	.	.	.	.	.						II 10	V625	.	.	.	.
Bruguiera exaristata (T)	.	.	.	.	.	.						I +	IV 85	I 25	.	.	.
Excoecaria agallocha (T)	.	.	.	.	.	.						II +	V 86	I 1	.	.	.
Aegialitis annulata (sh)	.	.	.	.	.	.						I 5	II 30	V455	.	.	.
Avicennia marina (sh)	.	.	.	.	.	.						I 75	I 30	V264	.	.	.
Rhizophora stylosa (T)	.	.	.	.	.	.						II 1	II 10	II 27	IV370	.	.
Ceriops tagal (T)	.	.	.	.	.	.						II 1	III180	.	V339	.	.
Avicennia marina (T)	.	.	.	.	.	.						.	.	.	III 640	.	.
Bruguiera gymnorhiza (T)	.	.	.	.	.	.						.	.	.	IV188	.	.

3.2.2 Grasslands and herbfields. The following types have been observed:

- (A) On coral sand or mixed sand and shingles the *Lepturus-Wedelia* community is an ‘inland’ grassland particularly well developed on Turtel V. This is the only community where the phosphatosensitive *Wedelia biflora* is fairly well represented and where plants like *Boerhavia glabrata* or *Sporobolus virginicus* which are indicative of high cation content of the soil are ruled out by competition (table 1, col. 2). The total plant cover is here relatively high of the order of 90 to 100%.
- (B) On seabird cays like Eagle Is. or to a lesser extent on Turtell V the central area is devoid of the woodland pointed by Domm’s model. Instead of it a mosaic of very mixed vegetation types (table 1, col. 3) is recorded including a *Sporobolus* grassland usually confined to samphires, exclusive clumps of the guano tolerant *Boerhavia glabrata*, a *Lepturus-Wedelia* grassland community in places with a lower phosphate content, a secondary dune herbfield with *Thuarea* on moving coral sand and finally groves of *Argusia argentea* or clumps of *Capparis sepiaria* and *Canthium coprosmoides* interspersed among these grasses and herbs communities (De Sloover & Liégeois 1997, De Sloover & Dufrêne 1999).
- (C) The *Lepturus-Canavalia* closed grassland is an open grassland covering to a large extent the old coral rubble ridges like those commonly observed on low wooded islands (Nymph, Turtell

Is., etc.). This specific poor community is dominated by *Lepturus repens* and creepers like *Canavalia maritima* and *Ipomoea macrantha* and herbs like *Euphorbia tannensis* (table 1, col. 4). This grassland is studded with shrubs like *Capparis lucida* and/or *Myoporum acuminatum* and depending on the favoured scale could be interpreted as a savanna as did Fosberg (1976) for describing a closely related community from Christmas Is. The 'Lepturus meadow' previously described by this author from drier zones in the Central Pacific like the Marshall Is. becomes a savanna or a dwarf shrub savanna when including shrubs or subshrubs.

3.2.3 The scrub and low trees belt. Five scrub communities have been recognised:

(A) On vegetated sand cays beyond the pioneering herbfield a more or less continuous belt of shrubs and low trees settles on the beach-crest; breaks in that belt are only accidental and either induced by storm on possibly dead shrubs either manmade or fostered by man. *Scaevola taccada* and *Argusia argentea* are among the most frequent shrubs of that belt. They form a dense scrub with small trees like *Cordia subcordata* or climbing shrubs like *Derris trifoliata* (table 1, col. 5). *Suriana maritima*, *Premna serratifolia* and *Colubrina asiatica* are also frequent components of that community.

(B) The problem of *Casuarina equisetifolia* stands on sandy coral cays (not shown here) has to be dealt aside. As seadrifters *Casuarina* seeds germinate between pioneering creepers or grasses of the upper strand open herbfield or even on bare sand; plantlets of even age are easily observed in great numbers and generate thick groves here and there. But this is quite a random occurrence and years can go by without any setting up. So that each narrowly delimited *Casuarina* stand of even a few trees points to a former strandline. Time passing the *Casuarina* forest lays down its 'needles' which build up a thick layer inhibiting seedlings of most species and old stands undergrowth are almost devoid of any shrub or herb. Very old *Casuarina* trees can outlast their former pure stands as isolated trees in mixed woodland. Although frequent in the littoral scrub *Casuarina equisetifolia* is regarded here as an opportunistic species rather than a regular constituent of the littoral scrub belt.

(C) Irrelevant to that scrub belt an open mosaic of shrubs, creepers, herbs and grasses may take up the central part of some sandy cays as well as the wide old shingle levees on the low wooded islands. Most of them are seabird islands and as such experience an unusual plant succession as already described under 2 B hereabove. Characteristic species are *Capparis lucida*, *Ipomoea macrantha* or *Premna serratifolia*. Eagle Is. and the sand cay of Turtell V are good examples (De Sloover & Liégeois 1997, De Sloover & Dufrêne 1999).

(D) A dense 3 to 5 m high scrub looks like a stage heralding the woodland since most of the woodland species are already found within. In other respects this apparent seral stage seems at a steady state particularly as it is situated on wind scoured tops of cays like Turtell or Nymph Is. A fairly high number of characteristic shrubs makes up that scrubby woodland like *Aglaia elaeagnoides*, *Eugenia reinwardtiana* or *Planchonella obovata* (table 1, col. 6). Other less frequent species in that community are *Maytenus marginatus*, *Cassine melanocarpa*, *Ixora klanderiana* and *Opilia amentacea*.

(E) With only few other species *Pemphis acidula* may form a dense scrub community on outer shingle ridges or as outposts on the inner upper rock platforms of the low wooded islands (like Nymph and Turtel Is.) where salt water is regularly flooding the shrubs even underneath the rubble ridges (table 1, col. 13). On sandy cays or on beaches built onto rocky islands this community is uncommon.

3.2.4 Woodland on sand and sand-shingle cays.

Larger or older islands like Masthead Is. and specially Green, Turtell V and Nymph Is. are totally or partly covered with dense woodland or scrub-woodland. Nevertheless structure and composition of those woodlands are quite different

according first to the latitude and thus the rainfall régime, secondly to the age and development of the island. Nesting seabirds act upon the actual climatic woodland too.

(A) The *Pisonia* woodland. On the whole length of the GBR numerous sand cays show a *Pisonia grandis* woodland. Nevertheless most of them are on the Capricorn and Bunker group cays like Heron, Masthead and Nord West Is. Further north Bushy Is. and in the northern section CairnCross or Douglas Is. are the best sites for that tree (Walker 1991). In fact *Pisonia grandis* woodlands are widespread in a great part of the central and western Pacific (Mueller-Dombois & Fosberg 1998) from French Polynesia and the Society Islands, Cook Islands (Western Polynesia: Vostok and Caroline Is.), central Polynesia (Washington Is., Ellice Is. in the Line Islands group), in Micronesia (Palau, Gilbert and Marshall Is. up to Marcus Is.).

We are only referring here to sand cays or motus (on atolls) covered with the woodland ecosystem which could be described as follows: monodominant broadleaf indopacific forest ecosystem, growing on coral sand and producing an acidic raw (pH < 6.0) humus overlaying a phosphatic exploitable hardpan (Fosberg 1976). This ecosystem seems linked to roosting seabirds colonies mainly of Black Noddies (*Anous minutus*) and is present even under dry oceanic climate; it is less frequent in higher rainfall areas where it experiences fiercer competition. Under most favourable conditions few species thrive in the undergrowth and the ground layer is devoid of any herb or grass (table 1, col. 9).

(B) The *Terminalia* rainforest. Some other wooded cays are made up by a pluristratal forest with *Terminalia* species like *T. catappa* and/or *T. microcarpa* as the dominant trees (De Sloover 1992). They appear on both sides of the equator under low latitudes in particular on Torres strait cays near Cape York or nearby Thursday Is. Off the northern PNG coast Laing Is. has the same littoral forest as the nearby lowlands but its composition is partially at variance with a rich assemblage of trees like *Intsia bijuga* or *Celtis latifolia* and the vine *Mucuna gigantea*. On the Bismarck Is. the situation is not far from that one. Further south Green Is. (Australia.) shows also a rainforest with *Terminalia* in a sector where rainfall is decidedly higher (table 1, col. 8).

(C) The *Manilkara-Diospyros* scrub-woodland. A third woodland type has set up on sand cays of the low wooded island type in the northern section of the GBR under a tropical monsoon climate (table 1, col. 7). They experience a dry season in winter and a wet intermission from November to March. Up till now it has only been recognized on the Turtell and on Nymph Is. but Stoddart & Fosberg's report (1991) lets suspect that Two Isles has or has had a similar forest. That woodland in question, the *Manilkara kauki-Diospyros maritima* forest is an evergreen, dense, sclerophyll and multistratal forest with a close canopy and a sparse groundcover (De Sloover & Dufrêne 1999). *Celtis philippensis*, *Glycosmis pentaphylla* and *Mimusops elengi* are frequent components of the shrub storey.

3.2.5 Samphires communities. If mangroves are absent, this group of communities forms the outermost zone of terrestrial vegetation either on cemented platform or on sandflats with very shallow flooding by the sea.

(A) On seabird sand cays like Eagle Is. a *Sesuvium portulacastrum* closed herbland sets up on the upper strand ledges where salt sprays regularly wet the community which is also enriched by birds droppings (De Sloover & Liégeois 1997). That community has a very low specific diversity and is furthermore made up of *Salsola kali* and *Ipomoea pes-caprae* (table 1, col. 10).

(B) On cemented shingle platforms of low wooded islands – like Nymph or Turtell Is. - near the high tides limit *Sesuvium* thrives also extensively where it grows to form 'clonal' swards. At the same level a variant of that paucispecific succulent community is dominated by *Sporobolus virginicus* (table 1, col. 11) which is able to form herbfelds with many mangrove saplings species like *Aegialitis annulata*, *Osbornia octodonta*,... (unpublished data).

(C) On the lower platforms where they are soaked at high tide those swards are enriched with genuine samphire species and form a community (table 1, col. 12) with *Suaeda australis* or/and *Sarcocornia quinqueflora* (De Sloover & Dufrêne 1999).

3.2.6 The mangroves. Though they stay at the interface between terrestrial and marine ecosystems mangroves are dealt with hereafter since their first signs as plantlets or even saplings were already obvious in the samphires (cf. hereabove). They are only fully developed on the low wooded islands like Turtell or Nymph Is. or on PNG cays like Laing Is. Study of their ecology is paradoxically well suited on those cays where gradients are not so progressive as they are along tidal channels or estuaries on the mainland. Four ecological groups were separated on the basis of 40 phytosociological relevés.

(A) The first group occurs toward the rear of mangrove sometimes in contact with samphires (table 1, col. 14). Communities are here dominated by *Osbornia octodonta* where the rare *Batis argillicola* is most frequently associated with *Suaeda australis* on sandy mud (unpublished data).

(B) In association with *Bruguiera exaristata* and *Excoecaria agallocha*, *Lumnitzera racemosa* makes up the second ecological group (table 1, col. 15). This group is frequently found fringing the rear of tidal mangroves made up by the fourth ecological group recognized on the low wooded islands and dominated by *Rhizophora stylosa* and *Ceriops tagal*.

(C) Spreading out more seaward than the samphires the *Avicennia-Aegialitis* dwarf mangrove is a stunted closed shrubland flooded each tide and thriving on the windward reef flat; their stands are either scattered on the eroded platform either edging ponds undermining piling up shingles (De Sloover & Dufrêne 1999). This looks as a specific poor community without syngenetic links with samphire communities (table 1, col. 16).

(D) The *Rhizophora-Ceriops* mangal (table 1, col. 17) takes up more sheltered spots than the former particularly in small bays, behind outcrops like the tombolo ridge on Nymph Is or in moated lagoons. The community is at best in stretches of water remaining in direct contact with the open sea like in Nymph Is. central lagoon (unpublished data).

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Ethnobotanical research for increased knowledge on biodiversity at the Laboratory of Tropical and Subtropical Agriculture and Ethnobotany, University of Gent: its situation at the beginning of a New Era

Patrick Van Damme & Xavier Scheldeman

University Gent, Laboratory for Tropical and Subtropical Agriculture and Ethnobotany,
Coupure links 653, B-9000 Gent, Belgium

Abstract. – *Ethnobotanical research at the Laboratory of Tropical and Subtropical Agriculture and Ethnobotany started in 1991 with a first project in Namibia, southern Africa. Other research initiatives in Africa were subsequently initiated in Senegal, Togo, Morocco (Quercus suber), Egypt (with an extension into Israel; both Mediterranean area; Pistacia spp.), Kenya (multipurpose trees for use in agroforestry) and of late in Tanzania. Since 1994, the Laboratory is also operational in Latin America. A first ethnobotanical project focused on local fruit species in southern Ecuador, with a small excursion into sangre de drago (Croton spp.). Subsequently, research was started in Bolivia (Cochabamba-based but with research activities both in the altiplano and Amazon forest areas), and since 2000 in Cuba. In Asia, the laboratory is supporting and monitoring ethnobotanical research and new crop development in Guizhou and Hunan Provinces (China) as part of an IFAD-funded development programme. The Laboratory's research approach is presented and detailed examples are given from the above projects.*

Samenvatting. – *Ethnobotanisch onderzoek voor een betere kennis van de biodiversiteit aan het Laboratorium van Tropische en Subtropische Landbouw en Ethnobotanie, Universiteit Gent: de toestand bij het begin van een Nieuw Tijdperk. Ethnobotanisch onderzoek aan het Laboratorium van Tropische en Subtropische Landbouw en Ethnobotanie ging van start 1991 met een eerste project in Namibië, zuidelijk Afrika. Andere onderzoeksinitiatieven in Afrika werden achtereenvolgens opgestart in Senegal, Togo, Marokko (Quercus suber), Egypte (met een uitbreiding naar Israël; in beide landen aan de Mediterrane zijde, betreffende Pistacia spp.), Kenia (boomsoorten met meervoudige toepassingen in de land- en bosbouw) en recent in Tanzania. Sinds 1994 is het laboratorium ook werkzaam in Latijns-Amerika. Een eerste ethnobotanisch project betrof lokale fruitsoorten in het zuiden van Ecuador, met een kleine uitbreiding naar de 'sangre de drago' (Croton spp.). Vervolgens werd onderzoek opgestart in Bolivia (gestationeerd in Cochabamba, maar met onderzoeksactiviteiten in de altiplano en het Amazonewoud), en sinds 2000 in Cuba. In Azië steunt en begeleidt het laboratorium ethnobotanisch onderzoek en de ontwikkeling van nieuwe gewassen in de Guizhou en Hunan provincies (China), als onderdeel van een ontwikkelingsprogramma van IFAD. De onderzoeksmethode van het laboratorium wordt voorgesteld en geïllustreerd met uitgebreide voorbeelden uit bovenstaande projecten. Vertaald door de redactie.*

Résumé. – La recherche ethnobotanique en vue d'une connaissance accrue de la biodiversité au Laboratoire d'Agriculture et d'Ethnobotanique Tropicales et Subtropicales, Université de Gand: sa situation au commencement d'une Nouvelle Ere. La recherche ethnobotanique au Laboratoire d'Agriculture et d'Ethnobotanique Tropicales et Subtropicales a démarré en 1991 avec un premier projet en Namibie, en Afrique méridionale. D'autres initiatives de recherche ont débuté subséquemment au Sénégal, au Togo, au Maroc (*Quercus suber*), en Egypte (avec extension à Israël; tous deux zone méditerranéenne, sur *Pistacia spp.*), au Kenya (arbres à destinations multiples pour l'agroforesterie) et dernièrement en Tanzanie. Depuis 1994, le Laboratoire opère également en Amérique latine. Un premier projet s'est focalisé sur des espèces locales de fruits en Equateur méridional, avec une petite incursion dans les 'sangre de drago' (*Croton spp.*). Ensuite, une recherche a commencé en Bolivie (basée à Cochabamba mais avec des activités de recherche à la fois sur l'Altiplano et dans la forêt amazonienne), et depuis 2000, à Cuba. En Asie, le Laboratoire supporte et surveille une recherche ethnobotanique et le développement de nouvelles cultures agricoles dans la province de Guizhou et de Hunan (Chine), projet faisant partie d'un programme de développement du Fonds IFAD. L'approche de recherche du Laboratoire est présentée et des exemples détaillés tirés des projets mentionnés plus haut sont donnés.. Traduit par la rédaction.

Keywords: medicinal plants, domestication, new crop development, taxonomy

Abbreviation: IFAD, International Fund for Agricultural Development

1 Introduction

Tropical forests and tropical areas in general take our fancy. They are overwhelming, exotic and often very green. They are (or sometimes merely seem) an immense source of resources and knowledge: numerous inhabiting plants and animals have been described and studied, whereas others still remain undescribed, unknown and thus often unused. But there seems little time left for research to try and describe and get to know all there is, as forests and natural vegetation in general are quickly disappearing because of human interventions such as mining, agriculture and logging. Forests are the modern times' Eldorado, which are up for grabs... Luckily enough ethnobotanists, biologists, medical institutes, pharmaceutical industry and governments have 'discovered' tropical forests for what they are: a source of vegetative wealth. Costa Rica for one found that their reasonable and sustainable exploitation can earn a considerable amount of money. Its *Instituto Nacional de Biodiversidad* has engaged in a long-time collaboration with Merck, one of the biggest pharmaceutical firms in the world. The money is used to revamp national research infrastructure and finance biodiversity inventories and protection/maintenance.

In 1992, tropical forests covered an area of some 11 million km². Each year, however, some 18 million ha disappear, which is more than 1.5 % per year. They currently cover some 6 % of the earth's land surface, but contain at least 60 % and possibly up to 90 % of all plant and animal species known to exist on our planet. In the Neotropics, they account for some 90,000 Angiosperms, whereas in Asia there are 'only' some 35,000 and in Africa 30,000 higher plant species which are present in this type of vegetation (Wijnands & al. 1993). Thus, it is the richest ecosystem in the world. In the case of South America, the unique biodiversity found in the Amazon, which is the result of a conjunction of natural disasters (glacial periods) and less drastic events (land slides, earthquakes, fire, drought,...), is increased by the fact that the area is transected by the Andes which explains much of the observed variations.

More specifically, and as an example, biodiversity in the neotropics can be quite high. There are examples where on a 40 ha plot more than 1,500 different plant species have been determined (Ecuador, Tena area; Izco, personal communication). On any hectare it is possible to find up to 30

specimens with a stem diameter > 10 cm (cf. the temperate forest situation in Belgium where the number of specimens per ha with similar dimensions often is as low as 15). Especially the canopy layer still has many secrets to surrender. New species are being described each day. However, good and especially recent floras are scarce. Major inventories are only undertaken with great reluctance and in a fragmented way. *Flora brasiliensis* (von Martius, 1840-1906) is a comprehensive work comprising some 23,000 species, but largely out of date. Other, more recent attempts, were stopped before completion, e.g. *Flora Brasílica*, or only deal with local and regional floras (Campbell & Hammond, 1989). The *Flora Neotropica* (UNESCO) tries to fill this gap, but the work will take a long time to be completed. What goes for living plants, also applies to the medicinal compounds they contain: only some 10 % of the 'known' flora, i.e. some 25,000 higher plant species, has been analysed exhaustively for its active compounds by 'modern' science, whereas the number of species used by the people living in the Amazon alone is much higher.

The people living in these tropical areas and forests know the plants and animals living in their direct environment, know which are useful and those that are dangerous. This knowledge differs from traditional society to traditional society, as natural conditions and the concomitant vegetation types, differ from area to area. Also: people who are performing any form of agriculture will have other knowledge acquired than (forest-dwelling) hunter-gatherers, the livelihood conditions and survival strategies being quite different. Much of this knowledge, however, is still inaccessible or difficult to interpret as it is often contained in terms, expressions and/or rituals that go with another worldview and way of thinking. Each society focuses on specific organisms, as it considers these to be important (as a source of food or medicine, or because they are poisonous, or for religious reasons). This factual/punctual knowledge is often complemented by information about the mechanisms that guide life in the forest. This is often deducted from the observation of individual species. Experience shows that this kind of knowledge is more developed in agrarian communities.

Knowledge about plants and vegetation dynamics is part of a broader outlook on life, and is often shrouded in symbolism. Most people do not make a clear distinction between what we might call nature or culture, or between things that have always been there ('nature') and things that have been developed or created by man ('culture'). They do not use any specific terminology. However, in their mind they seem to differentiate between things belonging to nature and culture. In the words of Van den Berg (1990, in de la Barra 1999): *Los habitantes de estas zonas perciben la ecología no como objetivo en sí, sino como parte de un universo en el cual las necesidades del hombre y las del carácter espiritual son interrelacionadas de manera dinámica buscando continuamente un equilibrio entre las partes*. When the environment/land is used, the supernatural is always somewhere there to guide this use. Traditional cosmology often refers to and is interlinked with nature/culture. Ethnobiological information can thus only be understood in its cultural context: an ethnopharmacologist who goes and collects information from the forest, takes away information from the larger whole to which it belongs. By ignoring this, interesting/valuable information can become lost. Cultural context parameters and perceptions will differ from place to place and person to person. In some societies, specific knowledge is limited to women or men, and can only be tapped by the 'right', i.e. gender-correct or culture-sensitive person.

Traditional life style is being threatened by modern society. However, the more traditional and 'weaker' societies are quickly and effectively stamped by more modern and dominant ways of living. Our own research has shown this to occur time and time again, e.g. Topnaar in Namibia; Wolof/Fulani in Senegal; the Bedouins in the Negev Desert, Israel; etc. In most cases, these ethnic groups were shown to have abandoned their traditional life style for a more Western behaviour, taking over Western habits but also products. In the case of the Negev Bedouins, extensive ethnobotanical field work in 1995 revealed traditional Bedouin nomads to know only some eight plant species for different uses, the knowledge systems on medicinal plants having been lost because of the omnipresence of Israeli run health posts where medicines are being dispensed for

free or at very low prices. The Topnaar living in the Namib desert still know many plant species as they use some 140 species out of the 400 to 500 growing in the desert, but most of the knowledge is confined to small groups of elderly people, the younger generation having been recuperated by the Western life style.

Traditional people have considerable plant-related knowledge. In a number of countries, traditional forest people are directly interviewed and tapped for their knowledge by researchers. In the case of medicinal plants, local healers help Western researchers in finding out what plants (and plant parts) are used by whom against what diseases and ailments. Plants are collected, registered, and analysed in the laboratory for active compounds. If and when this research is successful and yields new medicine, the people that have provided the initial clues and information about their uses/usefulness should have a share in the proceeds. In general terms the pathway presented here, also is the approach followed by the Laboratory of Tropical and Subtropical Agriculture and Ethnobotany, University Gent, Belgium when performing ethnobotanical research.

2 Ethnobotany and ethnobotanical research

The first step in trying to find interesting plants in numerous cases is an ethnobotanical research which focuses on traditionally living people and societies. Ethnobotany is a scientific discipline in which botanists and anthropologists/sociologists collaborate in trying to collect information about plant use by traditional people. Ethnobotany is a multidisciplinary science that uses competences from different disciplines to complement the information collected by both botanists and sociologists. Socio-linguists, ecologists, cultural analysts,... all come to give additional insight and explicative background on the data gathered. More specifically, ethnomedicine or medical ethnobotany concentrates on medicinal plants, and their uses.

Traditional medicine is a rich source of information. A number of societies have developed very intricate systems that are intimately linked to their culture and cultural history. Famous examples include China and India which also preserved their medicinal knowledge in writing: *Ayurveda* or *Siddha* in India, or *Pen-tsao* in China. The latter is opposed to (or differs from) the African and South American contexts where this knowledge belongs to and is guarded by limited numbers of initiated. Their knowledge is obtained through experience ('trial and error') and transmitted orally, and *not* in written form.

Ethnobotanical research consists of interviews with and consultations of knowledgeable people and, in the case of medicinal plants, professional healers and the people initiated in the specific medicinal practice, producers of traditional medicine and, of course, the patients that are treated with the products. Ethnopharmacology has a broader approach and tries to gather info on whatever disease and remedy in any environment.

Ethnobotany will try to find out which plant species or variety is used for what end use or in what preparation. Describing ethnobotanical uses and values of plants in a correct and, if possible, universally accepted way is of utmost importance if and when research on useful, and thus also medicinal, plants wants to be relevant for a broad user group. Ethnopharmaceutical questions focus on how traditional medicine is prepared: which plant parts are used and what are the treatments they are exposed to so that they would become effective. Ethnopharmacological questions are dealing with the effectivity and *modus operandi* of the medicine as it is described, claimed and/or expected. The ethnomedical questioning deals with the utilization of the product: in what case of which disease and what can be the results one can expect of its application.

3 Examples from the field: ten years of ethnobotanical research experience in the tropics

Ethnobotanical research at the Laboratory started in 1991 with a thorough investigation of the ethnobotany of the Topnaar (ex-Hottentots) living in the Namib desert (Kuseb river bed and Sesfontein area) and Walvisbay of Namibia. Although only some 400 to 500 higher plant species live in the desert, the Topnaar use some 140 species for a diversity of applications. From Namibia, the Laboratory's interests shifted towards West Africa. Ethnobotanical research became part of a broader research effort in which vegetation assessment and development of a sustainable management model of a deciduous forest zone in the Middle Casamance area of southern Senegal were the prime focus. Subsequently, an ethnobotanical survey was a secondary objective in the assessment of the impact of small dam constructions on the environment in northern Togo. In both cases, ethnobotany was integrated in a broader assessment effort, and the results were used to get a better idea of the present situation of biodiversity and the environment in general, and formed part of the models proposed to change and improve local situations.

In the case of Senegal, the data collected helped to point out priorities in selecting species to be protected or properly managed, or to be developed as 'crops'. This latter theme is a very important one, and will be shown to be a constant element in the Laboratory's research approach: no ethnobotanical surveying without the ultimate objective of applying the knowledge collected for the development of plants into crops, or medicine from plants. One of the ideas that underpins this philosophy is that this is one of the ways to protect biodiversity. Through the income they can ultimately generate, ecosystems can be protected against over-exploitation, whereas sustainable cropping usually is a valuable alternative for indiscriminate harvesting. In doing so, the Laboratory uses and helps in developing (new) statistical methods that can help in quantitatively assessing relative importance of plant species found to be interesting.

Ethnobotanical research in Africa continued in Morocco where it was part of a nature education programme focusing on the Marmora forest area of Rabat; here ethnobotanical information was to be used to develop education modules to be exhibited in an information centre intended to tell the public at large about the properties and the wealth of this wild cork oak tree forest (*Quercus suber*). In East Africa, the Laboratory collaborates with the International Centre for Research in Agro-Forestry (ICRAF) to study multi-purpose tree species that are currently found in the traditional farming systems of Kenya. Farmers' preferences and species' properties are matched to yield good candidates for domestication and ultimately diffusion in the area. In earlier days, the Laboratory had done extensive research into a locally important succulent species, *Euphorbia tirucalli*, which had been earmarked by the Kenyan government to be grown as a crop for diesel fuel production. Field experiments focusing on such agronomical aspects as propagation, irrigation/water use, fertilization and phytopathology, were complemented by laboratory research into plant physiology, and salt and drought stress resistance/tolerance. This again highlights one of the approaches of the Laboratory, i.e. to integrate different aspects of plant biology research (*sensu lato*) so as to get an as complete idea about any species' properties as possible. In the case of *E. tirucalli*, practical research on cropping aspects was complemented by fundamental and applied plant physiology research, the results of which gave insight in plant production dynamics and could be translated in practical cropping solutions. In other cases (see *infra*), biotechnological techniques are used to characterize germplasm collected and/or to (re)confirm and/or (in)validate taxonomical classifications.

In Northern Africa and the Middle East, the Laboratory collected germplasm of wild *Pistacia* species. The countries visited included Morocco, Tunisia, Egypt, Israel, Syria and Jordania. Germplasm collected was planted in two field plots in Israel and Egypt, and partly *ex situ* in a Ghent University greenhouse, for botanical and agronomical characterization. Part of the research focused and focuses on salt and drought resistance of wild accessions in view of developing

rootstock that can be used in commercial *Pistacia vera* cultivation. Initial germplasm collected in the Mediterranean has in the meantime been complemented by material from Iran (*P. mutica* and *P. khinjuk*) brought by Iranian students. Of late, similar research has started on wild almond species. The *Pistacia* programme is a spin off of an ethnobotanical research that had been executed on request of the Ben Gurion University, Be'ersheva in 1995, and had as major objective to study the ethnobotany of the Bedouins living in the Negev desert. Although results were not too exciting, the Bedouins only knowing and using some eight plant species for diverse purposes, the botanical exploration of the Negev desert had evidenced some interesting plant species, of which wild *Pistacia* species had shown promising features both on the level of ecology and agronomy.

Since the mid nineties, the Laboratory has started a number of ethnobotanical projects in South America. Ecuador (fruit species), Bolivia (medicinal plants) and Cuba (plants showing pesticide and allelopathy properties) have been and/or still are focal points for applied ethnobotanical research.

For the specific case of Ecuador, the Laboratory did an ethnobotanical survey in southern Ecuador focusing on local fruit species. All in all, some 250 species were identified as edible; twelve are endemic, and three new species were described: *Carica palandensis*, *Ceratostema* sp. *Nov. ined.* and *Passiflora luzmarina*. A number of plants have multiple purposes and are not only used for food but also as medicine (Van den Eynden & al. 1999):

- *Cordia lutea* (*muyuyo*, *overal*, *uva*) is a shrub belonging to the Boraginaceae. A leaf decoction is used as an external disinfectant. An infusion of flowers is drunk to cure stomach ache and dysentery. The plant is sown in living hedges because it readily shoots after cutting.
- *Inga striata* (*guaba*, *guabilla*, *guaba de mono*, *guaba natural*, *guaba musga*; Fabaceae, Mimosoideae) is a tree which yields large pods whereby the sweet pulp (sarcotesta) is edible. Washing the hair with a bark decoction should increase its growth.
- *Prosopis juliflora* (*algarrobo*; Fabaceae, Mimosoideae) is a tree of 5 – 15 m tall; a syrup called *algarrobina* is made from the pods by cooking them in water, squeezing them and boiling the remaining liquid until it thickens. *Algarrobina* is eaten on bread or drunk with milk. A bark decoction is a strong purgative. A leaf and twig or bark decoction is a scurvy remedy. The tree is also used for fuel wood, timber and for fencing.
- *Psidium guineense* (*guayabilla*; Myrtaceae) is a small shrub (0.5 – 3 m tall) which yields edible fruits that are eaten raw or cooked; an unripe fruit decoction is drunk to cure diarrhoea, whereas a root decoction cures coughs.
- *P. sartorianum* (*arrayán*) yields edible fruits: they are consumed raw or macerated in alcohol; a root decoction is drunk as a remedy for liver complaints.
- *Solanum americanum* (*mortiño*; Solanaceae) is a herb with white flowers in small inflorescences; the black fruit is only 6 mm in diameter. These can be used to prepare *chicha morada* (or: red *chicha*); a plant decoction is drunk to cure flu, colds, headaches, infections and nervous disorders. The fruit juice is dripped into the eyes to treat cataracts.
- *Guazuma ulmifolia* (*guásimo*; Sterculiaceae) is a tree that produces dry spherical, black fruits (2-3 cm in diameter); the sweet fruits can be chewed; a fruit decoction or syrup cures coughs. Fruits are also used as cattle fodder – the tree is used as fuel wood and for fencing.
- *Celtis iguanaea* (*uva*, *uña de pava*, *huevo de pava*, *mogroño*, *cacumba*; Ulmaceae) is a tree or a vine which produces axillary orange fruits of 1.5 cm in diameter with a single large seed; it grows in dry and humid areas, both at the coast and in the Amazon, between 600 – 1,500 m. The fruits are eaten raw. The plant sap can be used to cure coughs and flu. The wood is used for fuel.
- *Agave americana* (*méjico*, *penco*; Agavaceae) is a plant that can grow up to 2 m tall. Its green-bluish rosetted leaves have marginal and terminal spines. It flowers once after 10-20 years and then dies; it is found planted in living hedges between 1,100 and 2,100 m. The flower buds are

prepared as capers: after rinsing them 5 times in water they are boiled and pickled with lemon, onion and spices. A liquid called *mishque* is extracted from the plant: at the start of flowering, when the top of the plant opens up to release the flowering-stalk, the core is cut out of the plant and the wound left for a few days. Then a hole is made in the base of the plant, where the *mishque* will collect. The liquid is collected daily for about a month, whereby the sides of the hole are scraped each time. *Mishque* is drunk as a kidney remedy, is used to prepare colada by boiling it with barley flour or is fermented into an alcoholic drink. It is also used to fatten pigs.

- *Juglans neotropica* (nogal; Juglandaceae) eventually grows into a tree of 12 – 25 m high. It produces spherical green fruits of 6 cm in diameter with one seed. The seeds or walnuts are eaten raw or prepared in sweets. A syrup made of the seeds or the leaves is drunk in milk to cure anaemia. The leaves can be used to prepare herbal teas. The wood is used for furniture; the fruit peel and tree bark are used to dye wool.

In Asia, the Laboratory is only involved in one ethnobotanical effort. It is supporting and monitoring ethnobotanical research and new crop development in Guizhou and Hunan Provinces as part of an IFAD-funded development programme (IFAD = International Fund for Agricultural Development).

4 Conclusions

The Laboratory of Tropical and Subtropical Agriculture and Ethnobotany has been actively doing research on ethnobotany and domestication of interesting plants over the last ten years. In fact, it put ethnobotany on the Belgian research map and agenda, and is now amongst the only units active in this field in the country and surrounding areas. In the future, the Laboratory will continue to address ethnobotanical research needs in the broad tropical world. It will therefore cooperate with institutes in Belgium and elsewhere. Focus will remain on ethnobotany, but with a great emphasis on domestication and new crop development as means to guarantee sustainable exploitation of natural plant resources. Research agenda will continue to be set as much as possible by partners in the South to guarantee that topics are indeed development-relevant for the local situation.

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Abstracts of other contributions on tropical biodiversity

(Note: Some abstracts of the proceedings are hard to classify under only one heading. Especially readers with an interest in tropical diversity should also check under the next chapter.)

Taxonomic pteridophyte research in Belgium

Ronnie Viane, Peter Chaerle, Kim Constandt & Lien Van den Heede

Pteridological Research Group, Department of Biology, Ghent University,
K.L. Ledeganckstraat 35, B-9000 Gent, Belgium; ronnie.viane@UGent.be

Pteridophyte research at Ghent University started with the investigation of stomata types by Van Cotthem in the late 1960's. Subsequent micromorphological studies included indument characters as well as perispore traits in various families.

Current taxonomic investigation is focussed on Aspleniaceae, a cosmopolitan fern family of more than 700 species showing remarkable ecological and morphological diversity. Plants are either terrestrial, epilithic (growing on various rock types) or epiphytic, and occur from sea level to over 4000 m altitude. Though most taxa are found in tropical montane rainforests and south-temperate regions, some groups are adapted to xeric or other extreme conditions. Islands and isolated mountains often harbour endemics, and only very few tropical species occur on more than one continent (e.g. *Asplenium monanthes*, *A. aethiopicum*). No monographs or revisions exist.

Within the family the xeric subgenus *Ceterach*, the confusingly similar afro-alpine taxa with dissected leaves and creeping rhizomes, the African *A. anisophyllum* group, and several Asian taxa get most attention to date.

Apart from herbarium material, our living collection is indispensable. It not only forms the basis for comparative morphological and anatomical research, but is also of use to the cytological investigations that are used to interpret our molecular studies (isozyme analysis and DNA sequencing).

Taxonomic Rubiaceae research in Belgium

Steven Dessein¹, Petra De Block², Suzy Huysmans¹, Elmar Robbrecht² & Erik Smets¹

¹ Laboratory of Plant Systematics, Institute of Botany and Microbiology, K.U. Leuven,
Kasteelpark Arenberg 31, B-3001 Leuven, Belgium; steven.dessein@bio.kuleuven.ac.be

² National Botanic Garden of Belgium, Domein van Bouchout, B-1860 Meise, Belgium

With circa 650 genera and 13,000 species the Rubiaceae are the fourth largest angiosperm family. They are essentially tropical and woody, but one fourth of the representatives are herbaceous and some of these occur in temperate regions. Rubiaceae are easily recognized at family level by decussate, entire leaves, presence of stipules, actinomorphic flowers and an inferior ovary. Systematically the family is relatively badly known: numerous problems at different taxonomic levels remain unsolved.

In Belgium there is a longstanding tradition of Rubiaceae research. Well-known Belgian botanists such as Camille Vermoesen (1882-1922), Emile De Wildeman (1866-1947), Jean Lebrun (1906-1985) and Walter Robyns (1901-1986) studied the family. All these botanists worked at or

in collaboration with the National Botanic Garden of Belgium. More recently, Ernest Petit and Elmar Robbrecht took the Rubiaceae research to a deeper level, with monographic studies on e.g. *Psychotria* and *Tricalysia*. A second Rubiaceae research group exists at the Laboratory of Plant Systematics (Katholieke Universiteit Leuven). Their research focuses on character research within the family, e.g. in the fields of wood anatomy and palynology. The intense collaboration between the two research groups has resulted in multiple publications on Rubiaceae systematics.

Research is undertaken at different systematic levels. Apart from monographic treatments of genera, detailed morphological and anatomical studies result in deeper insights in tribal and subfamilial phylogeny.

Taxonomical study of *Scirpus* s.l. (Cyperaceae) in the Andes

Sandra Dhooge & Paul Goetghebeur

Ghent University, Department of Biology, Laboratory of Botany, Ledeganckstraat 35, B-9000 Gent, Belgium

Sandra.Dhooge@UGent.be

From the Andes a number of small Cyperaceae are known which all look very similar. They grow in a open vegetation, called 'páramo', situated above the montane forest and below the permanent snowline and concentrated in the northwest corner of South America. Another part of the involved taxa grows in the Andean regions of Bolivia, Chile and Argentina.

All the species are characterized by one terminal spikelet or a group of closely clustered spikelets. Because clear diagnostic features are missing the species were put into the heterogeneous genus *Scirpus* sensu latissimo. All those species however belong to several other genera, including one new genus.

To reveal the natural relationships of the species, a morphological, anatomical and molecular analysis will be performed. The study material is composed of specimens from many herbaria and specimens which will be collected in Ecuador during this study.

Based on the first data of the morphological and anatomical studies, the presence of clear differences between the examined *Scirpus* species indicates that the genus can be split up into several genera including *Andinoscirpus* (undescribed genus), *Oreobolopsis*, *Trichophorum* and *Phylloscirpus*. Within the genus *Oreobolopsis* the presence of a second species became evident (Dhooge & Goetghebeur, submitted). The habit of this new species is very similar to *Trichophorum rigidum*. However, this species is distinct from a typical *Trichophorum* due to the presence of scale-like perianth segments, the most striking feature of *Oreobolopsis*.

In the near future molecular sequences of a few genes will be determined to understand the phylogenetic position of the genera within the Cyperaceae.

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Evaluation, restoration and management practices in the conservation of tropical, Mediterranean and temperate forest ecosystems

Nico Koedam, Sandrine Godefroid, Farid Dahdouh-Guebas, Vladica Sivcev, James G. Kairo,

Anouk Verheyden, Jared O. Bosire, Thierry Dubois en Paul T. Obade

Laboratory of General Botany and Nature Management, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussel, Belgium

nikoedam@vub.ac.be

The laboratory of General Botany and Nature Management partly concentrates on in situ conservation and management activities on two types of forest ecosystems in different geographic regions. In our temperate region efforts of rehabilitation of degraded areas is concentrated on one hand on forests in and around Brussels, e.g. Sonian Forest (Zoniënwood, Forêt de Soignes), and on

the other hand on cork-oak forests (North-Africa), whereas in tropical regions assessment, inventory, restoration and monitoring activities are entirely focused on mangroves (e.g. in Kenya, Sri Lanka, India en Mauritania). In both forest ecosystems remote sensing and geographical information systems are used as important research tools and regular fieldwork missions are set up in order to collect a time-series of data on fauna and flora. To put the results in a broader perspective, socio-economic and/or ethnobotanical studies are carried out in the same sites in order to understand the man-environment relationships and to draft more comprehensive guidelines with respect to conservation issues. As education should be an integral part of an effective management strategy, attention goes to the popular dispersion of research results such as through the internet, both for the research done in and around Brussels (<http://www.vub.ac.be/APNA/ICZO/iczo.html> or <http://www.vub.ac.be/APNA/jungle.html>) and for the mangrove research (<http://www.specola.unifi.it/mangroves/>).

Seaweeds as indicators of biodiversity in marine benthic ecosystems

Eric Coppejans, Olivier De Clerck, Frederik Leliaert, Tom Schils,
Henry Engledow, Jeroen Verbruggen

Ghent University, Department of Biology, Research Group Phycology, K.L. Ledeganckstraat 35, B-9000 Gent, Belgium
eric.coppejans@UGent.be

Seaweeds are often an important component of marine benthic ecosystems, especially those characterised by hard substrate. These marine algae (comprising the Rhodo-, Phaeo- and Chlorophyta) predominantly grow epilithically on rocky shores and coral reefs, or epiphytically on seagrasses and mangroves between the high tide level and the bottom of the photic zone. In the tropics some species are also able to grow on sandy or even silty substrates. Eutrophication stimulates, in particular, the development of green algae belonging to the genera *Ulva* and *Enteromorpha*. This "greening" of some coasts results in a decrease in species richness (alpha-diversity) of the affected biotopes. Depending on the biotope (e.g. substrate, level related to the tides, climate), indicator species may appear or disappear resulting in information about the "health" of the region (e.g. a coral reef under pollution stress by tourism infrastructure). Pro-actively, algal species composition can help decision makers to choose areas with the highest biodiversity when delimiting marine protected areas or nature reserves along shorelines under high recreation/commercial utilization pressure.

Species diversity of diatoms in the Northern Basin of Lake Tanganyika

Christine Cocquyt

Ghent University, Department of Biology, Section Protistology and Aquatic Ecology,
K.L. Ledeganckstraat 35, B-9000 Gent, Belgium; Christine.Cocquyt@UGent.be

The diversity and biogeographical distribution of the diatoms in the northern basin of Lake Tanganyika are examined and compared with the data available for the entire lake. Most of the studied samples came from the littoral zone in the northern basin. Spatial and temporal samples of planktonic, epilithic, epiphytic and epipsammic communities were investigated as well as samples from surface sediments. Most of the diatoms recorded are cosmopolitan, but c. 21% has a distribution restricted to Africa; c. 8% is endemic.

The highest species diversity of diatoms in the littoral zone was observed in the plankton (280 taxa). The lowest Shannon's biodiversity index and its equitability index seen among the communities studied at the northernmost part of the lake. ($H=2.502$, $J=0.6011$ and $H=3.158$, $J=0.8032$ for the diatom communities of the northern littoral station near Bujumbura and of the southernmost littoral station near Nyanza-Lac in Burundi, respectively). A north-south trend of increased diatom diversity and a change in species composition could be demonstrated. These

trends were particularly evident among endemic taxa belonging to the genus *Surirella*. Effects of a high sedimentation rate of the Rusizi River together with pollution originating from industrial and urban sources in Bujumbura, lay probably on the base of the decreased biodiversity among the diatom communities in the northernmost part of the lake.

Assessment of environmental quality using diatoms in Nairobi river, Kenya

George Ndiritu & Ludwig Triest

Vrije Universiteit Brussel, Algemene Plantkunde en Natuurbeheer, Pleinlaan 2, B-1050 Brussel, Belgium
gndiritu@vub.ac.be, ltriest@vub.ac.be

Environmental variables and diatom data were collected from Nairobi River, Kenya to study the response of diatom assemblages on natural and artificial substrates to water pollution. Fifteen stations were sampled, covering a distance of 60 km from the source. The river was experiencing agricultural, domestic and industrial pollution. Environmental variables data were described by quartiles and standard error, explored using PCA and cluster analysis, and analysed using spearman's correlation, ANOVA and multiple regression. Species data were analysed using, biodiversity indices. Multivariate analyses included the two way indicator species analysis (TWINSPAN) and cluster analysis for classification, canonical correspondence analysis (CCA) and detrended correspondence analysis (DCA) for ordination. Ecological indicator values were also used. The multivariate analysis revealed three types of gradients in both substrates. The first gradient represented the upstream stations, which corresponded to high oxygen. The second gradient was related to high agricultural pollution and had high NO_3 . The third group corresponded to both industrial and domestic pollution and included stations situated in lower parts of the river. Those stations had high measurements of total dissolved solids, total suspended solids and PO_4 . Species richness, diversity and evenness tended to be higher in the second group while high densities were recorded in the third group. Our results showed that the response of diatom assemblages to environmental change and substrate type was observed in species composition variation. Multivariate analyses and ecological indicator values revealed this response and were preferred to species diversity measures

Étude de la productivité des champignons comestibles de la forêt classée de Wari-Marô (Bénin)

André De Kesel¹, S. Nourou Yorou², Brice Sinsin² & Jean-Claude T.C. Codjia³

¹ Jardin Botanique National de Belgique, Domaine de Bouchout, B-1860, Meise, Belgique; dekesel@br.fgov.be

² Laboratoire d'Ecologie Appliquée, Faculté des Sciences Agronomiques, Université Nationale du Bénin, 01 BP 526, Cotonou, République du Bénin; nourou@avu.org

³ Centre International d'Écodéveloppement Intégré (CECODI), Abomey-Calavi, 01 BP 2759, Cotonou, République du Bénin

Ce poster donne l'inventaire des macromycètes comestibles, trouvés dans six types de formations forestières de la forêt classée de Wari-Marô (Bénin, Afrique de l'Ouest) en région Soudano-guinéenne. Un total de 30 espèces comestibles a été obtenu dans 18 placeaux (3 placeaux par formation). Les données de comestibilité ont été obtenues de la population locale et de la littérature. Le nombre de carpophores et la biomasse fraîche ont été quantifiés par espèce et par formation. Les macromycètes comestibles sont à 86.6% des espèces ectomycorhiziennes appartenant principalement aux genres *Amanita*, *Lactarius* et *Russula*. En une saison la production totale, toutes espèces confondues, varie de 0.2 à 225 kg matière fraîche (MF)/ha suivant la formation forestière. Les formations ouvertes (savane arbustive, savane arborée et les différents faciès de la forêt claire à *Isobertinia doka*) dominées par les Caesalpiniaceae fournissent le plus d'espèces comestibles, tant en richesse spécifique qu'en biomasse fraîche. Par contre, les formations denses

fermées (forêt dense de plateau et forêt riveraine) pauvres en Caesalpiniaceae enregistrent les plus faibles productions. *Lactarius gymnocarpoides*, espèce symbiote d'*Isobertia doka*, est la plus abondante de la mycoflore des formations à caractère de forêt claire. Les productions spécifiques varient d'une formation à une autre. Quelques cas spécifiques sont traités. Les productions des espèces sont le plus souvent concentrées en début de la saison des pluies (juin-juillet). Les espèces à production plus étalée sont peu fréquentes. L'étude démontre que les potentialités des macromycètes de la forêt classée de Wari-Maró, en tant que ressource forestière comestible ou produit forestier non-ligneux (PFNL), sont énormes. Les facteurs importants pour le succès de la valorisation des ressources mycologiques dans la région sont l'appétence des populations locales et des acheteurs, ainsi que l'abondance et la disponibilité des espèces dans l'espace et dans le temps.

Potential of cherimoya (*Annona cherimola* Mill.) in southern Ecuador

Xavier Scheldeman¹, José Vicente Ureña Alvarez², Veerle Van Damme³ & Patrick Van Damme⁴

¹ Ghent University, Coupure links 653, B-9000 Gent, Belgium, xavier.scheldeman@UGent.be (Corresponding author)

² Centro Andino de Tecnología Rural, Universidad Nacional de Loja, Casilla 399, Loja, Ecuador, agrcater@impsat.net.ec

³ Agricultural Research Centre (CLO), Burg. Van Gansberghelaan 96, B-9820 Merelbeke, Belgium; v.vandamme@clo.fgov.be

⁴ Ghent University, Coupure links 653, B-9000 Gent, Belgium; patrick.vandamme@UGent.be

Loja Province (southern Ecuador) is generally acknowledged to be located in the centre of origin of cherimoya (*Annona cherimola* Mill.), a promising Andean fruit that is cultivated on an increasing scale, with Spain, Chile and United States showing growing interest in its commercialisation. A global study of cherimoya in Loja Province realised from January 1996 till September 1999 gave valuable information for future crop development. Although cherimoya is very common, well known and appreciated all over the province, commercial cultivation has not yet developed and the trees are found in the wild or tolerated in farmers' gardens. Loja Province will be able to exploit its big potential for commercial cherimoya cultivation if and when the possibilities linked to the presence of wild cherimoya trees are optimally used and the difficulties resolved.

The potential lies with (i) optimal edaphoclimatological conditions for cherimoya cultivation (shown by the presence of wild cherimoya trees); (ii) a lot of pomological potential, due to the big variability, with the presence of some excellent accessions; (iii) presence of natural pollination, eliminating one of the factors that complicates commercial cherimoya cultivation elsewhere, and (iv) an excellent acceptance and appreciation by local consumers, ensuring a good market. The difficulties and problems to be solved are (i) the presence of native pests and diseases especially fruit fly (*Anastrepha* spp.), resulting in heavily infested harvests; (ii) generative propagation resulting in a very heterogeneous harvest of mediocre quality; (iii) lack of cultural practices as land preparation, use of fertilizers, irrigation, tree formation, etc. resulting in low and irregular annual yields, and (iv) lack of an adequate fruit transport system from faraway harvest points to points of sale resulting in damaged fruits. These problems, although relatively easy to resolve, result in low quality fruits and low prices leading to a lack of interest of local agrobusiness and the evident risk of loss of genetic diversity.

Potential of highland papayas (*Vasconcella* spp.) in southern Ecuador
 Xavier Scheldeman¹, José Parcemon Romero Motoche², Veerle Van Damme³,
 Veerle Heyens⁴ & Patrick Van Damme⁵

¹ Ghent University, Coupure links 653, B-9000 Gent, Belgium, xavier.scheldeman@UGent.be (Corresponding author)

² Fundación Científica San Francisco, Mercadillo y J. J. Peña, Casilla 332, Loja, Ecuador, fcsf@utpl.net

³ Agricultural Research Centre (CLO), Burg. Van Gansberghelaan 96, B-9820 Merelbeke, Belgium,
 v.vandamme@clo.fgov.be

⁴ AMINAL, Koning Albert II-laan 20 bus 8, B-1000 Brussels, veerle.heyens@lin.vlaanderen.be

⁵ Ghent University, Coupure links 653, B-9000 Gent, Belgium, patrick.vandamme@UGent.be

Southern Ecuador is considered to be a centre of biodiversity of the so-called highland papayas, Andean species of the recently rehabilitated *Vasconcella* genus, Caricaceae family. *Vasconcella* species in southern Ecuador grow mostly in the wild, above 1000 m altitude, and consist of *Vasconcella cundinamarzensis* V.M. Badillo, *V. stipulata* (V.M. Badillo) V.M. Badillo, *V. × heilbornii* (V.M. Badillo) V.M. Badillo, *V. candicans* (A. Gray) A.DC., *V. weberbaueri* (Harms) V.M. Badillo, *V. monoica* (Desf.) V.M. Badillo, *V. microcarpa* (Jacq.) A.DC., *V. parviflora* A.DC. and the new endemic species *V. palandensis* (V.M. Badillo et al.) V.M. Badillo. At this moment only the natural hybrid *V. × heilbornii* 'Babaco', commercially known as babaco, is getting attention on the continuously expanding subtropical fruit market and is grown at commercial level in Ecuador. Natural hybridization and presence of accessions of which the taxonomical position (at the species level) remains unclear, combined with a limited number of botanical studies suggest that taxonomy of *Vasconcella* in Southern Ecuador is still not completely explained. Nevertheless, local collections and characterization studies show that, from an agronomical point of view, these highland papayas show a big potential for the future. Organoleptic characteristics of some accessions and species are very promising, especially for use in juices and marmalades. Making use of natural or artificial hybridisation can even expand this potential. Analysis of the activity of the proteolytic enzyme complex (papain) of these local accessions and species shows that latex of unripe fruits possesses up to 15 times more proteolytic activity than papaya (*Carica papaya* L.) cultivars selected and grown for their high enzyme content. Some *Vasconcella* species, especially *V. weberbaueri* and *V. monoica*, show resistance against some important babaco root diseases as *Fusarium oxysporum* and *Meloidogyne incognita*, and could be used as a rootstock for babaco grafting. The potential of *Vasconcella* species, which needs further detailed study, is increasingly under threat as population is growing, putting pressure on fallow and forest land and concentrating on food and cash crops consequently neglecting little known native fruit crops and reducing the natural vegetation in which they occur.

Genetische diversiteit in *Citrus* populaties en hybriden (Vietnam)

Karolien Van Puyvelde & Ludwig Triest

Algemene Plantkunde en Natuurbeheer, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussel, Belgium
 karolien.van.puyvelde@vub.ac.be, ltriest@vub.ac.be

De genetische diversiteit van *Citrus* germplasma gebruikt door traditionele Vietnamese landbouwers werd onderzocht. Er werden vier populaties (*C. limonia*, *C. grandis*, *C. nobilis* uit Tuyen Quang en *C. nobilis* uit Ha Giang) en hybriden waarvan de moederplant steeds een *C. nobilis* was, onderzocht. Er werd een intraspecifieke (met de hybriden families waarvan de vaderplant een *C. nobilis* was) en interspecifieke groep (met hybriden families waarvan de vaderplant een ander species dan *C. nobilis* was) van hybride families bestudeerd. Op basis van 4 isozymen: malaat dehydrogenase (MDH), malaat (ME), esterase (EST) en peroxidase (POD) werd de verwachte heterozygositeit en fixatie index berekend. De populaties van *C. limonia*, *C. grandis* en *C. nobilis* van Ha giang waren zeer heterozygoot en monomorf wat een mogelijke aanwijzing was van clonaliteit. Enkel de *C. nobilis* van Tuyen Quang populatie had samen met de hybride families 2

(*C. noblis* x *C. reticulata* “Duong Canh”) en 3 (*C. noblis* x *C. sinensis* “Yen Bai”) een lage heterozygositeit. De intraspecifieke hybride families vertoonden geen verschil in isozymen ten opzichte van de *C. nobilis* populaties. Het waren allen nucellus embryo's. Bij de interspecifieke hybride families had enkel familie 16 (*C. nobilis* x “Satsuma”) een verschillend zymogram. Deze hybride families bestond uit zygotische embryo's. De genetische diversiteit binnen en tussen de populaties werd eveneens aan de hand van RAPD merkers berekend. Er werden net zoals in voorgaande onderzoeken, geen unieke loci gevonden binnen populaties van een soort op basis van RAPD. Enkel bij *C. nobilis* van Tuyen Quang werden er 2 polymorfe loci gevonden. De UPGMA van zowel isozymen als RAPD onderscheidde duidelijk de populaties van *C. limonia*, *C. grandis* en *C. nobilis* van elkaar. De genetische afstanden tussen deze soorten waren groot. *C. nobilis* van Tuyen Quang en *C. nobilis* van Ha Giang hadden een heel kleine genetische afstand. De PCO groepeerde alle hybride families bij de *C. nobilis* populaties. De UPGMA onderscheidde duidelijk de intraspecifieke groep en de interspecifieke groep van elkaar op basis van RAPD. Verder onderzoek op basis van andere technieken (vb. SSR) is nodig om meer polymorfisme te ontdekken.

Wild edible plants in southern Ecuador. Are they really wild?

Veerle Van den Eynden

Dienst Tropische en Subtropische Landbouw en Etnobotanie, Universiteit Gent,
c/o Braemore, Tytler Street, Forres IV36 1EL, Scotland; veerle.nick@sol.co.uk

Conventional distinctions between wild and domesticated plants have been challenged in the last decades. Many seemingly wild plants and natural ecosystems are actually managed by people and have been so for a very long time. An inventory of “wild” edible plants was carried out in southern Ecuador from 1994 to 1997, using ethnobotanical field techniques such as semi-structured interviews and plant collection trips with informants from local communities in the 16 different ecological areas. Many edible plants were collected from within the agro-ecosystem. Of the 354 species of edible plants recorded, 31% are being tolerated in fields, pastures or homegardens and 16% are actively introduced (and cultivated) in homegardens. Plant management may have important conservation implications for the species concerned, or maybe more importantly, for the species not involved.

The INIBAP banana collection, a service for genetic diversity: preservation and use

Ines Van den Houwe¹, Bart Panis¹, Suzanne Sharrock² & Ronny Swennen¹

¹ Laboratory of Tropical Crop Improvement, K.U. Leuven, Kasteelpark Arenberg 13, 3001, Leuven, Belgium

² INIBAP, Parc Scientifique Agropolis II, 34397, Montpellier Cedex 5, France

Recognizing the importance of bananas as staple food for millions of people in the developing world, the International Network for the Improvement of Banana and Plantain [INIBAP is a programme of the International Plant Genetics Resources Institute (IPGRI), a Future Harvest centre], took the responsibility for systematically collecting, conserving, characterizing and sharing banana genetic resources.

Over the past 17 years, INIBAP has assembled the largest *ex situ* collection of banana and plantain in the world. The gene bank, housed at the K.U. Leuven, Belgium, holds over 1,100 accessions, including a wide range of wild material, all categories of cultivated material, and elite germplasm produced by breeding programmes worldwide. In 1994, this collection was placed under the auspices of FAO within the International Network of *Ex Situ* Collections and is held in trust for the world.

Germplasm in the INIBAP Transit Centre gene bank is kept as shoot tip cultures under medium term storage conditions at low temperature (16°C) and reduced light intensity (25 $\mu\text{Mol/m}^2/\text{s}$), requiring subculturing on average once per year.

In the perspective of the establishment of a long-term gene bank, three cryopreservation protocols for meristem cultures have been developed. The first two methods are based on the cryopreservation of highly proliferating meristem clumps that are precultured for 2 weeks on sucrose (0.4M) enriched medium. In the first method sucrose precultured meristem clumps are directly frozen while in the second method precultured clumps are subjected to a vitrification treatment prior to freezing. A third method involves vitrification of individual meristems excised from rooted *in vitro* plants.

Linking conservation and utilization is crucial to realize the full potential of germplasm resources. From this point of view, the germplasm collection also serves to underpin research and development interests worldwide. Healthy clonal material is freely available on request. More than 50,000 samples were supplied to nearly 200 organizations in 88 countries between 1985 and 2000. The distributed germplasm was mainly used for screening (i.e. characterization and evaluation for desirable traits), for genetic improvement, basic research and direct use in production.

Germplasm conservation and dissemination activities at K.U.Leuven are funded by the International Network for the Improvement of Banana and Plantain (INIBAP) through a grant from the Directorate General for International Cooperation (DGIS-DGIC), Belgium.

Diversité des produits oléagineux provenant d'espèces sauvages en savane guinéenne de Côte d'Ivoire: usage par les Malinké du Département de Séguéla et perspectives de valorisation

Guy-Alain Ambé

Laboratoire d'Écologie, Faculté Universitaire des Sciences Agronomiques de Gembloux,
Passage des Déportés 2, B-5030 Gembloux, Belgium

En Côte d'Ivoire, le département de Séguéla est situé à 400 km au nord-ouest d'Abidjan, la capitale du pays. Située à la lisière de deux formations végétale, forêt dense sèche au Sud et savane guinéenne au Nord, la région se distingue par une diversité écologique relativement importante. On y rencontre aussi bien des formations denses (forêt dense semi-décidue, îlots forestiers, galeries forestières, etc.) que des formations ouvertes (forêt claire, savanes de type divers).

La biodiversité végétale dans ce milieu contraste avec le nombre limité de plantes couramment utilisées en alimentation. Les produits lipidiques proviennent essentiellement d'une espèce cultivée, l'arachide (*Arachis hypogea*) et d'une plante subspontanée, le palmier à huile (*Elaeis guineensis*). Si l'apport quantitatif en matières grasses peut être assuré par la consommation abondante de ces produits, les carences en acides gras essentiels restent un problème majeur. Cela s'explique notamment par la pauvreté dans les zones rurales, qui rend difficile l'accès à une alimentation diversifiée.

Une étude ethnobotanique réalisée dans la région a permis d'identifier 7 espèces sauvages produisant des graines oléagineuses inconnues ou peu connues pour leurs usages alimentaires : *Annona senegalensis*, *Carapa procera*, *Myrianthus serratus*, *Moringa oleifera*, *Parinari curatellifolia*, *Pentadesma butyracea*, *Ricinodendron heudelotii*. Ces espèces sont présentées et leurs potentialités aussi bien nutritionnelles que médicinales et industrielles, signalées dans la littérature, sont ici mises en évidence.

La valorisation de ces produits pourrait permettre d'accroître la diversité des ressources oléagineuses alimentaires dans les villages. Par la même occasion, une gestion rationnelle de cette biodiversité est susceptible d'apporter des devises aux populations rurales par la commercialisation d'huiles dont les propriétés intéressent certaines industries (fabrication de savons, de vernis, d'encre, etc.).

Biodiversity assessment of Cuban weed flora as a source of biological herbi- and pesticides
 Françoise De Cupere¹, Ina Vandebroek¹, Mayra Puentes², Sinesio Torres² & Patrick Van Damme¹

¹ University of Ghent, Department of Plant Production, Tropical and Subtropical Agriculture and Ethnobotany, Coupure Links, 653, B-9000 Gent, Belgium

² Universidad Central de Las Villas, Facultad de Ciencias Agropecuarias, Carretera a Camajuaní, Km 5½, Santa Clara, Villa Clara, C.P. 54830, Cuba

Use of medicinal and religious plants is ubiquitous in Cuba. The concept of allelopathy, however, is much less known and applied. Analysis of ethnobotanical and literature data showed there is a limited number of crops and wild plants that are locally known to have herbicidal properties. After preliminary screening and gathering of field data, *in vitro* germination tests have been initiated testing extracts of tobacco (*Nicotiana tabacum*), banana (*Musa* spp.), sunflower (*Helianthus annuus*), *Simarouba glauca* and *S. laevis* (syn. *Quassia*, fam. Simaroubaceae). All plants tested showed some allelopathic effect, and tobacco, sunflower and *S. laevis* even had a very strong effect. Where tobacco and *S. laevis* have seemingly the greatest impact on seed germination, sunflower has a more pronounced effect on the growth of seedlings.

The riparian flora and vegetation of the Botanical Garden 'Cupaynicú', Granma Province, Cuba
 Yakelín Sánchez Rodríguez¹, Cesar García Hernández¹, Françoise De Cupere² & Patrick Van Damme²

¹ Jardín Botánico 'Cupaynicú', Los Mameyes, Guisa 88200, Granma, Cuba

² Ghent University, Coupure links 653, B-9000 Gent, Belgium

The great diversity of plant species existing in Cuba is determined by a set of physical-geographical factors. The latter also explain the diversity of vegetative formations which can be divided in five large groups : forests, thickets, secondary vegetation, herbaceous vegetation and miscellaneous.

Within the types of forests, the gallery forest occupies an important place in the Cuban archipelago, due to its large hydrographic network. The gallery forest is associated with rivers' and rivulets' sides banks or shores. Its floristic composition depends mainly on the flora of the river's upper course and of the adjacent areas. In the Botanical Garden "Cupaynicú", this type of forest forms a significant part of its natural vegetation. Nevertheless, no studies have been undertaken up to this date in order to completely characterize its flora and vegetation.

As a result of the floristic study, a great diversity of species could be evidenced in this gallery forest with a low endemism. The floristic associations are mostly neotropical.

The gallery forest is composed of tree layers, a dense and continuous tree layer, a shrub layer and an herbaceous layer. In the upper part of the tree layer, lianas and epiphytes are present.

Characterization of the riparian flora of the Botanical Garden 'Cupaynicú', Granma Province, Cuba
 Yakelín Sánchez Rodríguez¹, Cesar García Hernández¹, Françoise De Cupere² & Patrick Van Damme²

¹ Jardín Botánico 'Cupaynicú', Los Mameyes, Guisa 88200, Granma, Cuba

² Ghent University, Coupure links 653, B-9000 Gent, Belgium

The gallery forest forms a significant part of the natural vegetation of the Botanical Garden 'Cupaynicú', Granma Province, Cuba. Following a floristic study of the area, a great diversity of species was evidenced, with a low endemism (see the previous study by the same authors, also presented in this event). The floristic associations are mostly neotropical. The principal mechanism for dispersal of diaspores in this kind of forest is by way of water (hydrochory). At the level of the

vegetation structure, the latter not only evidences the physiognomy of this vegetation, but also permits to make conclusions on habitat factors. Moreover, the variety of biological forms is closely associated to the existing biodiversity. In the following study, from all the species identified in the first study mentioned hereabove, the use patterns, dispersion mechanisms, biological types and leaf types (size and texture) were determined.

Almost all species identified in the gallery forest of the Botanical Garden 'Cupaynicú', have one or more use pattern(s): only 10.2 % did not have a specific application. Medicinal use is the utility pattern best represented.

As for the evaluated characteristics, they are conform to what might be expected from the kind of forest under study. Hydrochory is the most predominant dispersion mechanism, although it is mostly accompanied by another method. As for the biological type, the different forms of phanerotypes are most frequently present. Leaf size (mesophyll and macrophyll) and texture (chartaceous and membranous) also correspond to the morphological adaptations imposed by this kind of forest.

Forest community, structure and diversity of the coastal Cienfuegos (Cuba) thicket

Cristóbal Ríos¹, Aracelys Valiente², Francisco Dallmeier³, James Comiskey³, Ximena Londoño³,

Patrick Van Damme⁴ & Françoise De Cupere⁴

¹ Jardín Botánico Universidad Central de Las Villas, Facultad de Ciencias Agropecuarias, Carretera a Camajuaní Km 5½, Santa Clara, Villa Clara, Cuba

² Jardín Botánico de Cienfuegos, Calle Real No.136, Pepito Tey, Cienfuegos, Cuba

³ Smithsonian Institution, Washington D.C., 20560 U.S.A.

⁴ Ghent University, Coupure links 653, B-9000 Gent, Belgium

This study provides information on the floristic composition, structure and diversity of the coastal dry forest community which can be found between Cienfuegos and Casilda, south central Cuba. A 1 ha permanent monitoring plot, was established in the protected area Guanaroca at Punta Gavilanes (22°10'N, 80°24'W) using SI/MAB methodology. The plot is situated at approximately 20 km from the city of Cienfuegos on a red fersiallitic soil with flat karst consisting mainly of coastal coral limestone (substrate is of coral origin). Precipitation is low in the rainy season (May to November) and erratic in the dry season. The vegetation physiognomy is generally shrubby and characterized by a xerophytic flora consisting of large succulents such as *Dendrocereus nudiflorus* and *Agave* spp. The dense underlayer, with an average height of 2 m, is composed of *Allophyllus cominia*, *Erythroxylum* spp. and *Eugenia* spp. A relatively dense canopy with an average height of 5 m is dominated by species of *Eugenia*. There are epiphytes associated with *Lysiloma bahamensis* (*Tillandsia fasciculata*, *Tillandsia* spp.), and to a lesser degree, a variety of orchids. Members of some 30 families have been found, the best represented being Annonaceae, Cactaceae, Erythroxylaceae, Fabaceae, Mimosaceae, Myrtaceae, Rubiaceae, and Sapotaceae. The most common species with diameter at breast height greater than 10 cm are *Lysiloma bahamensis*, *Bursera simaruba*, *Eugenia* spp., *Luehea platypetala* and *Antirhoea lucida*. Prominent elements of the shrub layer (5 m high approx.) and the lower canopy layer are *Eugenia* spp., *Allophyllus cominia* and *Erythroxylon* spp. The number of herbs and epiphytes is low. Endemic medicinal and ornamental plants, birds, reptiles and crustaceans species are found within the plot.



The database BIODIV "Biodiversity Resources in Belgium" <http://www.br.fgov.be/BIODIV>

Guido Rappé, Alain Vander Velde & Kristien Busschots

National Botanic Garden of Belgium, Domein van Bouchout, B-1860 Meise, Belgium
biodiv@br.fgov.be

Abstract. – BIODIV or 'Biodiversity Resources in Belgium' (<http://www.br.fgov.be/BIODIV/>) is an inventory of the expertise concerning biodiversity available in Belgium. It is not limited to the biodiversity of the Belgian territory. The inventory concerns the research done and collections/databases kept in Belgium. The inventory has been constructed as a relational database that can be consulted, corrected and completed on the web. Titles of research and collections are connected to researchers/curators at the institutions involved (public and private): universities, research institutes, botanical gardens, zoos and aquaria, museums, nature education centres, associations, journals, libraries, documentation centers, private companies, nature reserves management, field stations, administrations,... It can be consulted via people, institutions or keywords of a taxonomical, geographical or miscellaneous nature. BIODIV also includes a list of reference literature on biodiversity, offers an interactive agenda to announce events, and has a news page and links to other websites related to biodiversity. At this stage BIODIV contains a lot of information available in Belgium. It is of interest to scientists, students, governmental organisations and NGOs, developing countries in need of information... BIODIV provides Belgian information on biodiversity to related national and international initiatives and acts as a national node for the European projects BioCISE and BioCASE. The Belgian biodiversity research can also be viewed in terms of the Core Program Elements and the Special Target Areas of Research of the international biodiversity program DIVERSITAS. The database is kept as up-to-date as possible. Both professionals and non-professional experts in the field of biodiversity are invited to join the database BIODIV. Forms to do so are available online. This project is an initiative of OSTC, the Belgian Federal Office for Scientific, Technical and Cultural Affairs. It is carried out at the National Botanic Garden of Belgium at Meise.

Samenvatting. – De databank BIODIV "Biodiversity Resources in Belgium" (<http://www.br.fgov.be/BIODIV/>). BIODIV is een inventaris van de expertise betreffende biodiversiteit beschikbaar in België. Ze is niet beperkt tot de biodiversiteit van het Belgische grondgebied. De inventaris heeft betrekking op het Belgisch onderzoek en de collecties/databanken beheerd in België. De inventaris is georganiseerd als een relationele databank die kan geraadpleegd, verbeterd en aangevuld worden op het internet. Onderzoeksonderwerpen en collecties worden gekoppeld aan de verantwoordelijke onderzoekers/beheerders en de instelling(en) waaraan ze verbonden zijn (zowel private als overheidsinstellingen: universiteiten, onderzoeksinstellingen,

botanische tuinen en arboreta, dierentuinen, aquaria en dolfinaria, musea, natuureducatieve en veldbiologische centra, verenigingen en tijdschriften, documentatiecentra, studiebureaus en zelfstandige consultants, administraties,... De databank kan geconsulteerd worden vanuit verschillende invalshoeken: u zoekt een onderzoeker of een bepaalde instelling of een onderzoek/collectie aan de hand van een of meerdere taxonomische, geografische of andere trefwoorden. BIODIV bevat ook een keuzelijst van referentieliteratuur voor de studie van de (voornamelijk Belgische) biodiversiteit, biedt een interactieve agenda aan om evenementen (symposia, studiedagen,...) aan te kondigen, en beheert een nieuwspagina en een lijst van interessante links naar andere websites omtrent biodiversiteit. Op dit ogenblik bevat BIODIV een schat aan informatie beschikbaar in België. De website is van belang voor wetenschappers, studenten, overheidsinstanties en beleidsmakers, NGO's, ontwikkelingslanden op zoek naar informatie. BIODIV is toeleverancier van Belgische biodiversiteitsinformatie aan verwante nationale en internationale initiatieven en fungeert als nationaal knooppunt voor de Europese projecten BioCISE en BioCASE. Het Belgisch biodiversiteitsonderzoek kan ook geraadpleegd worden volgens de Core Program Elements en de Special Target Areas of Research van het internationale biodiversiteitsprogramma DIVERSITAS. De databank wordt zo up-to-date mogelijk gehouden. Zowel professionele onderzoekers als gedreven amateurs ('independent experts' in de databank) worden uitgenodigd hun onderzoek en expertise op het vlak van biodiversiteit kenbaar te maken via de databank BIODIV. Formulieren hiervoor zijn online beschikbaar. Vooral in bepaalde takken van de botanie is de inbreng van de amateur zeer belangrijk: denk maar aan de vele verenigingen en individuen die zich interesseren in en nuttig onderzoek verrichten aan paddestoelen, mossen, hogere planten, aan checklists en verspreidingspatronen. Een discipline als floristiek zou quasi ondenkbaar zijn zonder de bijdrage van de niet-professionele onderzoekers (die veel talrijker zijn dan zij die er wel hun dagtaak kunnen aan wijden). Het project BIODIV is een initiatief van de DWTC, de Federale Diensten voor Technische en Culturele. Het is gevestigd in de Nationale Plantentuin van België te Meise.

Résumé. – La base de données BIODIV “Biodiversity Resources in Belgium” (<http://www.br.fgov.be/BIODIV>). BIODIV est un inventaire de l'expertise de la biodiversité en Belgique. Cet inventaire n'est pas limité à la biodiversité du territoire belge. Il prend en considération la recherche belge ainsi que ses collections et bases de données. L'inventaire consiste en une base de donnée relationnelle pouvant être consultée, corrigée et complétée via internet. Les titres de recherche et des collections sont reliés aux chercheurs/curateurs des institutions concernées (publiques et privées): universités, instituts de recherche, jardins botaniques, zoo et aquarium, musées, centres d'éducation sur la nature, associations, journaux, bibliothèques, centres de documentation, compagnies privées, centre de gestion de réserves naturelles, stations de recherche biologique, administrations,... La recherche sur internet peut s'effectuer via le nom d'une personne ou d'une institution mais aussi par mots clés géographiques, taxonomiques ou autres. BIODIV reprend également une liste de références bibliographiques traitant de biodiversité, fourni un agenda consignant les événements et nouveautés et possède une page de liens menant vers d'autres sites web spécialisés dans la biodiversité. A ce stade, BIODIV contient énormément d'informations disponibles en Belgique. La base de données intéresse les scientifiques, les étudiants, les organisations gouvernementales et les ONG, les pays en voie de développement en quête d'informations. BIODIV est fournisseur d'informations belges sur la biodiversité à d'autres initiatives nationales et internationales et joue le rôle de noeud national dans les projets européens BioCISE et BioCASE. La recherche sur le site peut également être visualisée via la classification DIVERSITAS (Core Program Elements and the Special Target Areas of Research). La base de données est régulièrement mise à jour. Professionnels et amateurs sont invités à encoder leurs sujets de recherche dans notre base de données BIODIV. Des formulaires sont disponibles online. Le projet BIODIV est une initiative des SSTC, Services

fédéraux des affaires scientifiques, techniques et culturelles. Il est mené au Jardin Botanique National de Belgique à Meise.

Key words: Belgium, CBD, biodiversity, website, database, research, collections

Abbreviations: CBD, Convention on Biological Diversity;
BioCISE, Resource Identification for a Biological Collection Information System in Europe;
BioCASE, a Biodiversity Collection Access Service for Europe;
GBIF, Global Biodiversity Information Facility.

1 Introduction

In 1992, Belgium, along with 169 other partners, approved the ‘Convention on Biological Diversity’ (CBD), accepted during the UN Conference on environment and development (Rio de Janeiro, June 5 th 1992). The 20 of February 1997, the Belgian government ratified the ‘Verdrag inzake biologische diversiteit – Convention sur la diversité biologique’.

This convention was born from the growing awareness and concern at a planetary scale regarding the rapid decline of fauna and flora of the Earth. Many life forms have become extinct, are living at the verge of extinction or under severe threats. Extinction has been a geological process since life began, but the speed at which it occurs now, largely due to human interfering, has never been witnessed before. Influential scientist talked about the ‘biological diversity crisis’ to emphasize the phenomenon (Wilson 1985). For a general reading about the importance and challenges regarding biodiversity and an overview of some international and national major initiatives, see e.g. Rappé & Robbrecht (1999). For more information on the CBD and its follow-up in Belgium, see Van Goethem (1999). Unfortunately the latter failed to mention the subject of this contribution, the project BIODIV, one of the very first initiatives taken by the Belgian government in the follow-up and the spirit of the CBD.

Convention on Biological Diversity
(Rio de Janeiro, 1992)

Art. 1. Objectives

...the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources...

Art. 6. General Measures...

(a) Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity...

Art. 17. Exchange of information

1. The Contracting Parties shall facilitate the exchange of information, from all publicly available sources, relevant to the conservation and sustainable use of biological diversity, ...

2 Historical background

In order to make available, for the government and other institutions, information allowing them to meet their legal obligations, the then ‘Ministry of Social Integration, Health and Environment’ financed a study at the end of 1993 aiming at characterizing the existing capacity of Belgium in

studying and preserving biodiversity, and, on the basis of the performed consultations, make some suggestions for a national campaign.

This study led in 1995 to the drafting of two reports:

'Annuaire du potentiel scientifique belge en matière d'étude et de conservation de la biodiversité' ('Yearbook of the scientific Belgian capacity in the field of the study and preservation of biodiversity') et 'Analyse du potentiel scientifique belge en matière d'étude et de conservation de la biodiversité et propositions pour un plan d'action national' ('Analysis of the scientific Belgian capacity in the field of the study and preservation of biodiversity and proposals for a national campaign') and of a synthesis:

'Caractérisation du potentiel scientifique belge en matière d'étude et de conservation de la biodiversité et propositions pour un plan d'action national' ('Characterization of the scientific Belgian capacity in the field of the study and preservation of biodiversity and proposals for a national campaign').

The Biodiversity group of BELNET (Belgian Research Network), a communication network for scientific research and the Belgian public sector, wished to carry on with this report. Therefore a new initiative was launched in 1996 within the 'Biodiversity workgroup': BIODIV or 'Biodiversity resources in Belgium'. In order to ensure a broad and rapid diffusion of information, all information is available for consultation and can be modified on Internet. The website effectively started in June 1997.

This initiative is financed by the the Belgian Federal Office for Scientific, Technical and Cultural Affairs (OSTC) and based at the National botanic Garden of Belgium.

3 Mission

The 'Biodiversity Resources in Belgium' database, BIODIV, has been put in charge of a double assignment:

In the first place it is aiming at the realization of a survey of the studies achieved in Belgium about biodiversity; this survey includes the researchers and their research themes as well as the biological collections.

The second part concerns the survey of the databases gathering biological data, with, as far as possible, the setting-up of an 'on line system' (via Internet) giving access to those databases or to a part of their contents.

4 Contents and accessibility

In accordance to the request of the Biodiversity workgroup of BELNET and of the members of the attending commission of the BELNET-BIODIV project, the contents of the database includes first and foremost all the aspects concerning the knowledge of wild biodiversity. The relational database consequently essentially provides nowadays informations about wild organisms (i.e. non-cultivated): plants, animals, fungi, seaweeds, unicellular organisms and bacteria.

BIODIV informs about the research achieved in the field of biodiversity, all its possible levels: genetic diversity, species, populations, living communities and ecosystems, or even nature conservation as a whole.

The distinction between natural biodiversity and manipulated biodiversity is not quite clear in some cases. Agriculture and horticulture essentially deal with breeds and cultivars. Nevertheless, many aspects of the biology and ecology of the domesticated or cultivated species are linked with the wild biodiversity: pollinisators, predators, parasites, pathogen microorganisms... Databases of

edible or ornamental organisms including ancestral types encompass in the same way information about wild biodiversity.

The purely fundamental research, whether biochemical, genetical, physiological, toxicological, morphological, ethological, or ecological, based on one single taxon, often as a model, are not kept in the database. On the other hand, such comparative researches between close taxa are certainly linked to biodiversity. The biological collections kept in Belgium are also included.

The website (<http://www.br.fgov.be/BIODIV>) is in English, with the homepage also in French, Dutch, German and Spanish, and a help page. Four large entities have been distinguished: institutions, persons, research topics and biological collections.

The functional database unit is a triplet, a coupling of three different elements: research group or lab + name researcher + research topic or biological collection. This solution proves very flexible: several people linked to the same lab and different topics, several people working on the same subject,...

4.1 Institutions

The term 'institution' has been considered in a broad sense; each institution possesses one or several subdivisions such as department, working group, laboratory, secretarial office, museum...

The information about institutions can be searched for via their names in different languages, part of the names or their abbreviation. For each subdivision of an institution, addresses, phone number, fax, e-mail address and possibly a website address of the staff, research topics and present collections are given.

In order to make the search for information on Internet easier, the institutions have been classified and are also directly accessible via the following categories:

- University
- Non-University college
- Research Institute
- Zoo, Aquarium, Dolfinarium
- Botanic Garden, Arboretum
- Museum
- Nature education centre, Visitor's centre
- Association, Society, Working group
- Journal, Serial
- Library, Documentation Centre
- Independent expert, Naturalist
- Private Company
- Nature Reserves Management
- Field Station
- Administration

The emphasize lies with professional research done at the universities and research centers.

4.2 People

The people can be searched for on the website via their name, first name, both names or part of the names. Besides information such as phone number, fax, e-mail (possibly internet address), professional address, the fields of biodiversity activities are provided: biodiversity related research and other tasks alongside their main charges: editor of a journal, curator of a collection, manager of a database...

4.3 Fields of Research

For each field of research, a research title and possibly a starting and closing date of research are described. If that research is involved in a larger research project, the latter is also mentioned.

A wide field has been provided allowing to display a more elaborate summary of the researches and/or to include bibliographical references on the topic.

Three categories of keywords have been provided to exploit each research topic: taxonomical, geographical and others (disciplines/habitats...). These keywords do not appear on the screen but act as research keys; they are used to search information in the database. The latter can be found via one or another category of keywords or via a combination of keywords. Each research topic is linked to one or several researchers working at one or more institutions.

4.4 Biological collections

Biological collections have been described specifying the number of samples, possibly the number of species and of type-specimens. The term collection has to be considered in a broad sense, including databases: elements of those collections can be biological samples, pictures of biological elements, lists of observations.

Collections are described in the way research topics are: with an informative title and keywords in the same categories (taxonomical, geographical or other). It has also been mentioned whether the collections are linked to an electronic database. BIODIV provides also - when possible - information research tools within those databanks when the latter are present on Internet.

Nowadays, the BIODIV-database includes about 300 institutions, 980 names of searchers, 2400 triplets institution-researcher-research topic, 2000 taxonomical keywords, 1600 geographical keywords, 6000 other keywords, 250 Internet links and 800 e-mail addresses.

4.5 Other services

BIODIV also includes a list of reference literature on biodiversity. These lists contain references to recommended literature for the study of biological diversity, meeting at least one of the following criteria:

- Literature needed for the study of a particular taxonomic group in Belgium or NW-Europe.
- Literature dealing with certain groups or territories abroad and having one or more Belgian authors.
- Literature published in Belgium by foreign authors.

Authors mentioned here and also present elsewhere in the database are highlighted and hyper-linked to these other aspects.

BIODIV also offers an interactive agenda to announce events, the only page that is freely and directly accessible for everybody. Furthermore there are a news page and links to other websites related to biodiversity, in Belgium and abroad.

5 National cooperation

BIODIV is "the" server of metadata concerning biodiversity in Belgium. It is also the eldest Belgian initiative in the framework of the Convention on Biological Diversity. As such it became a reference, a biodiversity resource itself for all other bodies, authorities, initiatives that need biodiversity information, including the scientific community, governmental agencies and policy makers, students in biology, agriculture and environmental issues,... not to forget other related Belgian projects on biodiversity that were launched afterward, like the website of the Belgian Clearing House Mechanism of the CBD (CBD-B CHM) at the end of 1997, the server of metadata

on Africa METAFRO Infosys (1998), the Belgian Biodiversity Platform (BBPF, 2001) and the Belgian National Node of GBIF (BeBIF 2002).

BBPF e.g. will use BIODIV to analyse the Belgian scientific research and give advice and recommendations to the governmental policy makers. Together with our national partners, BIODIV shares a portal website biodiversity.be.

There is also exchange of data with the server SIBW (Système d'Informations sur la Biodiversité en Wallonie).

6 International cooperation

BIODIV has been acting as the Belgian focal point to the (EU-funded) European project BioCISE (Resource Identification for a Biological Collection Information System in Europe) and also acts as such for the (EU-funded) European project BioCASE (a Biodiversity Collection Access Service for Europe). Because of the headstart of BIODIV as a Belgian biodiversity facility, its example and expertise have been proven to be useful in the development of other similar national initiatives in other partner-countries in these projects.

BIODIV is also a partner of the European project Species2000Europe (EuroCAT) and participates in the TDWG (Taxonomic Databases Working Group) since 2000, mainly being interested in the TDWG Subgroup on Biological Collection Data. The Belgian biodiversity research can also be viewed in terms of the Core Program Elements and the Special Target Areas of Research of the international biodiversity program DIVERSITAS.

BIODIV can offer scientific information on the biodiversity of developing countries (e.g. articles 1 and 17 of the CBD), as far as these were collected by Belgian researchers or institutes.

Finally, BIODIV also acts as an 'ambassador' of Belgian scientific research.

7 Method

In order to make the collecting of data easier, two forms are available on the website: one for 'research', one for 'collection'. The top part, with data on the institution, the department and the person is the same in the two forms and, once introduced, is automatically repeated. All the data can consequently directly be forwarded to the BIODIV managers via the Internet forms. As soon as a form has been saved, the program launches a summary of all the recorded data, under the title FAX MESSAGE. The person is requested to print this summary, to sign it and to fax it to the managers.

This personal confirmation is needed because new accessions are never straightly introduced into the Internet-database. Sent in forms arrive in a waiting room, their contents is checked and entered in the BIODIV database server. Only then can they be transcribed to the website database.

All data present in the database can be modified at any moment ('Add or Modify'). Following some simple instructions, an old form can be called back in order to correct existing or communicate additional information.

8 Call

BIODIV offers the user an easy access to nowadays available information on biodiversity in Belgium. It functions at the same time as a phonebook, a fax directory, a list of postal addresses and e-mail addresses index, an Internet guide for Belgian institutions and websites and a metadata-bank on the diverse Belgian sources about biodiversity. The BIODIV contents is available for the

national and international community: researchers, students, governmental institutions and NGO, developing countries...that are in need of this kind of information.

In order to make of BIODIV a efficient source of information, we need your participation. Professional and non-professional researchers (keen amateurs) are invited to encode themselves with their research topics, collections, databases. Please visit the website or ask for forms by mail.

If you are already present in the database, we would be much obliged if you kept your data up to date. If you have not yet been recorded in the database or some of your colleagues have not been, please visit our website, select the 'add or modify data' key and send us your new or renewed data.

BIODIV is at your disposal, but also thanks to you. Biodiversity encompasses a broad field. Thank you in advance for your collaboration.

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Abstracts of miscellaneous other contributions

Biodiversiteitscrisis en DNA-technologie: uitdagingen voor de biologische systematiek anno 2001

Elmar Robbrecht

Nationale Plantentuin van België, Domein van Bouchout, B-1860 Meise, Belgium; robbrecht@br.fgov.be

De vooruitgang van de biotechnologie heeft de bioloog nieuwe mogelijkheden verschaft om de evolutie te reconstrueren vanuit gegevens aanwezig in hedendaagse organismen. Vergelijkende sequentiebepaling van gedeelten van het genoom domineert vandaag de systematische biologie. De menselijke vooruitgang heeft echter ook de 'biodiversiteitscrisis' veroorzaakt: de soortenrijkdom gaat niet alleen achteruit, ze wordt ook steeds meer verstoord. Ze kan voor alle groepen organismen wereldwijd niet snel genoeg in kaart worden gebracht. De biosystematicus moet daarom meer dan ooit een evenwicht vinden tussen vooruitgang van de kennis (lees fylogenetische reconstructie) en snelle aflevering van producten voor gebruikers. Hierbij moeten de middelen van de informatietechnologie aangewend worden om Flora's en Fauna's te herdenken.

The Tervuren xylarium supports phytodiversity research world-wide

Hans Beeckman

Royal Museum for Central Africa, Laboratory for Wood Biology and Xylarium,
Leuvense steenweg 13, B-3080 Tervuren, Belgium; hbeeckman@africamuseum.be

Trees and shrubs dominate the majority of the vegetation types. Secondary xylem is the most abundant terrestrial biotic tissue. From ancient prehistoric times the association between man and wood has always been very strong. Indeed wood is a very valuable and versatile material permitting to make buildings, furniture, tools and paper products. Even an extremely industrialised society can not function without the renewable natural resource that is wood. In developing countries more than 60 % of the energy needs are being covered by wood. Because of its omnipresence, wood is an important subject to endeavour and can be studied from different viewpoints: technology, botany, forestry, art history, ethnography, archaeology and palaeontology. Since the environment is a driving force for cambial activity, trees and shrubs register valuable ecological information in their lignified tissues. Decoding this information is a topic for ecology.

The wood collection housed at the Royal Museum for Central Africa in Tervuren and the Laboratory for Wood Biology linked to this xylarium are involved in different aspects of wood research. The domain of the xylarium is worldwide. It incorporates wood samples from 56,000 specimens and 13,600 botanical species. As such it is the second largest wood collection of the world. Wood from all growth forms producing secondary tissues are incorporated.

Three general research tasks of the Laboratory for Wood Biology are distinguished: (1) the study of the ecological wood anatomy in Africa South of Sahara; (2) contractual research related to wood anatomy and dendrochronology (geographical domain: world-wide) and (3) rendering of services most frequently implying the identification of the taxon of wooden objects (geographical domain: world-wide).

The first task involves verifying hypotheses concerning the ecological indicator value of wood anatomical features. Therefore, a database is being constructed consisting of microscopic observations of microtome slides from Central and West Africa. Many wood anatomical characteristics (vessel size, parenchyma type) show a strong relationship with general habitat conditions. By a dendrochronological approach ring patterns of African trees (mangroves of Kenya, Miombo woodland, semi-deciduous West-African dense forest, West-African tree and woodland savanna) are being analysed to study the climatic relationships and to design forest management plans.

The second task englobes a diversity of activities, all related to wood anatomy or dendrochronology: micro-photography of commercial woods, investigation of the wood quality of exterior joinery, dating of Brabantian altar pieces, study of European oak decline, examination of juvenile coniferous wood, archaeobotany and comparative wood anatomy for plant systematics.

The third task concerns the short term services related to the identification of the botanical taxon of wooden objects of many different kinds: art, commercial wood, archaeological charcoal and lignified wood. In this context CITES expertises are executed.

Scientific collaboration exists with many Belgian and foreign universities and research institutes.

Study on the morphology, ultrastructure, and typology of orbicules in Gentianales

Stefan Vinckier & Erik Smets

Laboratory of Plant systematics, Institute of Botany and Microbiology, K.U.Leuven,
Kasteelpark Arenberg 31, B-3001 Leuven, Belgium; stefan.vinckier@bio.kuleuven.ac.be

In the anthers of flowering plants, tiny ($< 4 \mu\text{m}$) granules may occur on the radial and innermost tangential wall of secretory tapetum cells. These granules are sometimes in close contact with the pollen grains, and are called orbicules or Ubisch bodies. Orbicules develop simultaneously with the growing pollen exine and are composed of sporopollenin, similar to the pollen exine.

The presence, morphological and ultrastructural diversity of orbicules are investigated in 129 species (99 genera), covering the families Gentianaceae, Rubiaceae, Apocynaceae s.l. (incl. Asclepiadaceae), and the segregated Loganiaceous families (Loganiaceae s.str., Strychnaceae, Gelsemiaceae, Geniostomaceae, and the Loganiaceae tribe Potalieae which is included in Gentianaceae), with scanning electron microscopy, light microscopy, and transmission electron microscopy.

Of the 129 species investigated, 95 species (73 genera), covering all the families included in Gentianales, possess orbicules. The results of this study, in which we investigated 46 Rubiaceae species (34 genera), bring the total number of Rubiaceae genera possessing orbicules to 36. In addition to previous reports on the presence of orbicules in *Catharanthus roseus*, 47 more Apocynaceae s.l. species (37 genera) were investigated in this study of which 33 genera possess orbicules. Furthermore, apart from *Exacum* and *Gentiana*, we investigated 5 more Gentianaceae genera of which four genera were shown to possess orbicules. In the heterogeneous Loganiaceae s.l. all 19 investigated species (13 genera) were shown to possess orbicules.

Orbicule types were defined, based on the observed morphological and ultrastructural variations of the present orbicules. The typology follows the treatment of orbicule types described for the rubiaceae subfamilies Cinchonoideae and Ixoroideae. In the Cinchonoideae, Huysmans et al. (1997) defined four orbicule types: spiny orbicules (**Type I**), microrugulate orbicules (**Type II**), smooth and rounded oblate orbicules (**Type III**), and irregular and folded orbicules (**Type IV**). Two additional orbicule types were defined by Vinckier et al. (2000) in the Ixoroideae: large flattened and irregular orbicules (**Type V**), and distinctly embedded orbicules (**Type VI**). The systematic value of these types has been tested by comparison with the most recent classifications in Gentianales.

Etude de la clonalité chez *Vaccinium myrtillus* (Ericaceae)

Thierry Albert, Olivier Raspé & Anne-Laure Jacquemart

Laboratoire d'écologie et de biogéographie, Université catholique de Louvain,
4-5 place Croix-du-Sud, B-1348 Louvain-la-Neuve, Belgium; albert@ecol.ucl.ac.be

Une population de myrtille, située dans la réserve de la 'Grande Fange' (Ardenne belge), a été analysée à l'aide de marqueurs RAPD (Random Amplified Polymorphic DNA) afin de déterminer la structure clonale de cette population. Un total de 26 marqueurs polymorphes ont été révélés par six amorces RAPD. L'analyse des résultats obtenus a permis d'identifier 32 clones parmi les 112 ramets échantillonnés. Le facteur le plus important donnant la structure à la population est l'extension limitée des clones. La dispersion des graines semble aléatoire, au sein du site étudié, et n'a donc pas d'effet structurant sur la population.

Non-marine diatoms from the Ile de la Possession (Crozet Archipelago, Subantarctic Region)

Bart Van de Vijver, Pieter Ledeganck & Louis Beyens

Universiteit Antwerpen (RUCA), Departement of Biology, Unit of Polar Ecology, Limnology & Paleobiology,
Groenenborgerlaan 171, B-2020 Antwerp, Belgium; bartvdy@ruca.ua.ac.be

Diatoms are commonly reported from waterbodies in the Antarctic and Subantarctic regions. They are considered to be one of the most abundant algal groups in both freshwater streams and lakes (Jones 1996). Based on both climatological and vegetational characteristics, Stonehouse (1982) described a distinct cold-temperate Subantarctic region, comprising several island groups such as the Crozet Archipelago.

Recently, an elaborate floristic and (paleo-)ecological study has been started on the Ile de la Possession, the largest island of the Crozet Archipelago, dealing with non-marine diatoms. Although many diatom taxa on the island are considered cosmopolitan, there are still a number of unusual forms that are typical for the Subantarctic region. Almost 250 non-marine diatom taxa have been found on the island, several of them appearing to be new for science. Descriptions of the new taxa are still ongoing.

Besides the morphological and taxonomic description of the present diatom flora, the definition of more appropriate autecological information for each diatom taxon forms one of the main themes of this general survey. This has resulted so far in several papers dealing with different aspects of the ecology of diatoms on the Ile de la Possession.

This lecture tends to give an overview of both the morphological and ecological work that is included in this survey.

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Botanische aspecten van het archeologische project te Sagalassos, Turkije

Leo Vanhecke

National Botanic Garden of Belgium, Department of Vascular plants, Belgium and temperate regions Unit,
Domein van Bouchout, B-1860 Meise, Belgium; Leo.Vanhecke@br.fgov.be

Het Sagalassos-project is een pluridisciplinair archaeologisch project van de K.U.Leuven dat onder leiding staat van prof. M Waelkens. Sedert 1996 wordt ook botanisch onderzoek verricht op de site en binnen het territorium van de historische stad. Een overzicht wordt gegeven van de botanische activiteiten met archaeologische relevantie. Het ingezameld materiaal en het vegetatiekundig veldwerk van ter plaatse laten ook toe specifiek botanische aspecten te ontwikkelen.

Diatoms from three different habitats in a high-arctic region (Zackenberg, Northeast Greenland)

Andy Van Kerckvoorde & Louis Beyens

Departement of Biology, Unit of Polar Ecology, Universiteit Antwerpen (RUCA), Limnology & Paleobiology,
Groenenborgerlaan 171, B-2020 Antwerp, Belgium; andker@ruca.ua.ac.be

When comparing the 3 major habitat types, the highest number of taxa, number of genera and diversity index is found in the aquatic samples. The soil samples show the lowest values for these variables.

A high number of taxa of the Zackenberg flora occur only in the water samples. Only few taxa are restricted to samples of soils and terrestrial mosses. In total 54% of the taxa are found exclusively in one habitat. About a quarter of the taxa are present in all three habitats. However, when looking to the contribution in the relative abundance, these taxa become very important. The abundance of taxa exclusively found in the aquatic habitats is only of minor importance.

The result of a classification (TWINSPAN) does not show a clear differentiation of the different habitats. Cluster 1 groups all soil samples and samples from the driest terrestrial mosses. Taxa with high abundances in cluster 1 were: *Caloneis aerophila*, *Diademsis contenta*, *Diademsis contenta* f. *biceps*, *D. perpusilla*, *Eunotia praerupta*, *Hantzschia amphioxys*, *Navicula atomus*, *Pinnularia borealis*, *P. borealis* var. *thuringiaca*, *P. curticostrata* and *P. obscura*. The majority of terrestrial moss samples were grouped in cluster 01. This cluster is characterized by *Caloneis arctica*, *Cymbella paucistriata*, *Eunotia fallax*, *Navicula gandrupii*, *Nitzschia perminuta*. Cluster 00 contains mainly water samples. Not surprisingly tychoplanktonic taxa (*Fragilaria* spp. and *Tabellaria flocculosa*) differentiate this cluster.

Diatom biogeography: patterns and processes

Koenraad Vanhoutte, Wim Vyverman, Koen Sabbe, Victor Chepurnov,

Koenraad Muylaert, Christine Cocquyt & Elie Verleyen

Ghent University, Department of Biology, Laboratory of Protistology and Aquatic Ecology,
K.L. Ledeganckstraat 35, B-9000 Gent, Belgium; koen.vanhoutte@ugent.ac.be

The diatoms are microscopic unicellular plants, which in spite of their tiny size (normally within the range of 0.01-0.1 mm) play an enormous role in the functioning of the biosphere. Their contribution to the global production of organic matter created on Earth through photosynthesis is estimated as 20-25%. Very recently, the results of sensitive, fine-grained taxonomical, biological and biogeographical studies have provided strong evidence that the widely accepted dogma that microorganisms are predominantly cosmopolitan does not apply in case of the diatoms. However, there is strong evidence for endemism in diatoms both at the generic and specific level, in particular in the southern hemisphere. Some of the major patterns and their potential historical causes are discussed.

World-wide systematics of the genus *Lactarius* (Russulales, Basidiomycota): a state of the art

Annemieke Verbeken, Ruben Walley, Jorinde Nuytinck & Pascale Van Rooij

University of Gent, Department of Biology, Laboratory of Botany, section Mycology,
K.L. Ledeganckstraat 35, B-9000 Gent, Belgium; Mieke.Verbeken@UGent.ac.be

The ectomycorrhizal, cosmopolitan genus *Lactarius* is studied morphologically and systematically. This study initially focused on tropical Africa, but now also concentrates on Europe and Australasia. It is estimated that about 350 species are known on a world-wide scale, but the real number could easily raise to 500.

For tropical Africa, about 85 species are accepted, all of them endemic to the continent. Central and East Africa are relatively well studied, recently more collections from West Africa were involved and this allows us to find out more about the distribution in the major phytogeographical zones and the specificity to certain host trees. Characters observed in the African species are often very different from those observed in species in the northern hemisphere.

Even in the well-explored European continent (with about 135 species present), some undescribed taxa occur and several species complexes remain unsolved. Nomenclatural problems give raise to discussion and misinterpretation. To solve the taxonomic problems in the popular section *Deliciosi*, the study of molecular characters is included. In this group we also concentrate on the study of the ectomycorrhiza, because *Deliciosi* are commonly used for artificial mycorrhization.

Tropical Asia and Australia are underexplored. Our recent studies have focused on Papua New Guinea and raised the number of recorded species from 2 to 27.

Special attention is given to the systematics within the genus and links on suprageneric level between the continents. Studies are planned to include molecular data as well as morphological data to develop a natural classification system within the genus and to obtain a better understanding of the phylogeny in the Russulales.

Molecular analysis of cyanobacterial community diversity and seasonal dynamics by clone library and DGGE on PCR-amplified 16S rRNA, in Esch-sur-Sûre lake

Christophe Boutte, Pierre Balthasart, Stana Grubisic & Annick Wilmotte

Laboratory of Algology, Dept of Plant Biology B22, University of Liège, B-4000 Liège, Belgium

C.Boutte@ulg.ac.be

In the framework of the project MIDI-CHIP, our aim is to assess the genotypic diversity of planktonic cyanobacterial populations of three European lakes (Luxembourg, Italy, Finland) and to study their variations and succession. The lake of Esch-sur-Sûre that we study is a mesotrophic lake, situated in North Luxembourg. During one year, the lake has been sampled each week in summer and monthly during winter. We have used 2 methods. On one hand, we have analysed 400 bp 16S rRNA amplified products by DGGE (Denaturing Gradient Gel Electrophoresis). We have excised particular bands and sequenced them. On the other hand, we have studied 1500 bp 16S rRNA amplified products in clone library, by sequencing unique clone. The obtained sequences have been analyzed with the ARB Software (Ludwig 1999) tools. The first results show a certain diversity in our summer samples, and the seasonal cyanobacterial variations seem to be quite high.

Estimating genetic diversity in autochthonous populations.

Case studies on *Quercus* sp. and *Iris pseudacorus*

Els Coart¹, Veerle Lamote^{1,2}, Erik Van Bockstaele^{1,2}, Marc De Loose¹

¹ CLO-Gent, Dep. for Plant Genetics and Breeding, Caritasstraat 21, B-9090 Melle, Belgium; e.coart@clo.fgov.be

² Ghent University, Dep. for Plant Production, Coupure Links 653, B-9000 Gent, Belgium

There is a tendency towards a more natural approach in nature conservation, especially in severely managed sites such as riverbanks and forests. These habitats are often repopulated with plants abundantly available on the market, most of them from foreign origin. The introduced plants, although from the same species, may constitute of very different genetic material in comparison to the original population. Therefore emphasis is laid upon the use of autochthonous material. Because autochthonous material has been under constant natural selection, it is believed to be the most adapted material for the local conditions. The aim of this study is to gain insight into the genetic diversity of autochthonous yellow flag (*Iris pseudacorus*) and indigenous oak (*Quercus petraea* and *Quercus robur*) populations. Yellow flag is commonly used for restoration of bank

vegetation. In general the material is grown up from seeds harvested in nature. When used for plantations no attention is given to the origin and genotype of the plant material. Oak is the most commonly planted species in Flemish forestry practice. Currently, only seeds from provenances are being used. These trees are selected upon growth characteristics such as vigour and form and often the exact origin is unknown. Following the more natural approach, field managers also want to breed from autochthonous relict populations for further afforestation. For both species knowledge on the genetic diversity and origin of autochthonous populations is necessary in order to apply suitable material. We used the AFLP-technique to conduct a study on the genetic diversity of Flemish populations of *I. pseudacorus* and *Q. species*. *I. pseudacorus* from the IJzer basin showed to be different from that of the basin of the Scheldt, which can be explained by the geographical and hydrological isolation of both basins. A high degree of genetic diversity was detected in the populations, although the AFLP technique allowed us to identify 3 ramets belonging to one clone. The results enforce the use of local material for the conservation of natural resources of yellow flag in Flanders (Belgium).

AFLP analysis of Flemish *Q. robur* and *Q. petraea* populations, showed a clear differentiation between species. No species-specific markers were found using 4 primer combinations, but marker frequency differences up to 71% were recorded between species. A small though significant differentiation was also revealed at the population level. Results of chloroplast analysis and morphological characterization will be compared with the AFLP data.

In search of species-specific markers in two hybridizing *Rhinanthus* species

Véronique Ducarme & Renate A. Wesselingh

Université catholique de Louvain, Unité d'Écologie et de Biogéographie,
Croix du Sud 4-5, B-1348 Louvain-la-Neuve, Belgium; wesselingh@ecol.ucl.ac.be

The principal goal of this project is to study the origin and the dynamics through time of natural hybridization between two annual plants *Rhinanthus minor* and *Rhinanthus angustifolius* (Scrophulariaceae). The occurrence of hybrids between these species and their flower morphology was largely documented by Kwak (1978). In our study, we will correlate flower morphology with individual genetic identity. Thus, we will be able to track introgression events even when hybrid flower morphology has become indistinguishable from pure species. Jointly, we will study the mechanisms of reproductive isolation between these species in order to explain the direction of introgression.

First, we had to develop molecular markers to differentiate the two species, distinguish the hybrids and attribute a hybrid index.

To this end, we used RAPDs and tested one hundred primers on individuals of the two species coming from pure populations. Then, interesting primers were tested on hybrids as well. We obtained 11 good markers from 6 different primers. These molecular tools, together with a species-specific chloroplast DNA marker that we are currently searching for, will be used to study the genetic structure of mixed populations.

Genetic consequences of population turnover in a tree metapopulation

Olivier Raspé & Linda Dhondt

Université catholique de Louvain, Unité d'Écologie et de Biogéographie,
Croix du Sud 4-5, B-1348 Louvain-la-Neuve, Belgium; raspe@ecol.ucl.ac.be

Based on several models of metapopulation structure and dynamics, the following predictions have been made: (1) genetic differentiation should be higher among newly founded populations compared to old populations; (2) genetic diversity within populations is expected to be lower in recently founded populations. We tested those theoretical predictions in a metapopulation of

Sorbus aucuparia (Rosaceae), an entomophilous, bird-dispersed tree, which was previously shown to be characterised by high levels of gene flow. The studied metapopulation is located on the Plateau des Tailles (Upper Ardenne, Belgium). In the studied area, the landscape is a mosaic of heathlands and bogs, meadows, *Picea abies* plantations and beech woods. The *S. aucuparia* metapopulation is age-structured, with young populations colonising clearings in *P. abies* stands, whereas old populations are found on old heathlands (some of them within nature reserves).

Both nuclear (isozymes) and chloroplast (PCR-RFLP) markers were used to assess genetic diversity and population differentiation. For both genomes, we have shown that population differentiation was significantly higher among recently founded populations. Genetic diversity was lower in young populations for both isozyme and chloroplast markers. These results demonstrate that even in a species characterised by high levels of gene flow, metapopulation dynamics may significantly increase genetic differentiation and decrease genetic diversity within populations. From a conservation point of view, we have shown that human activities, i.e. clearings in *P. abies* plantations, have an impact on the genetic diversity maintained within and among *S. aucuparia* populations. The old populations located in nature reserves probably play a role in buffering the effects of population turnover, notably as reservoirs of genetic diversity.

Genetic diversity and structure in fragmented populations of *Primula vulgaris* and *P. veris*

Fabienne Van Rossum, S. Campos De Souza & Ludwig Triest

Vrije Universiteit Brussel, Plant Science and Nature Management,
Pleinlaan 2, B-1050 Brussels, Belgium; fvrosum@vub.ac.be

Primula vulgaris (= *P. acaulis*) and *P. veris*, (Primulaceae) are diploid, insect-pollinated, obligately outcrossing (due to distylous self-incompatibility) long-lived perennials. In Flanders, *P. vulgaris* is a very rare, declining species, with a distribution restricted to a few areas in West-Flanders, whereas *P. veris* shows a patchy distribution. They occur in habitats that have been strongly fragmented and suffer from the intensification of the agricultural practices; their populations have been subdivided into small to relatively large patches, often isolated from each other.

We investigated genetic diversity and structure using allozyme markers (27 and 30 loci) in relation to population size, isolation and density, and in relation to its reproduction strategy (morph ratio), in 41 populations of *P. vulgaris* and in 24 populations of *P. veris* from Flanders.

P. vulgaris populations showed lower values of genetic variation than *P. veris* when comparing the same loci. In both species, small populations were found to have significantly less genetic variation (allelic richness and expected heterozygosity) but still maintained high levels of observed heterozygosity. A skewed morph ratio affected genetic variation, reinforcing the negative effects of population size. Small populations were found to be more differentiated than large populations. These results suggest genetic drift as a main cause of loss and differentiation in small populations. Populations of *P. vulgaris* showed isolation by distance. In *P. veris*, a geographical structure according to the regions (West-Vlaanderen and Oost-Vlaanderen) was found.

The life-history traits of the species – a self-incompatibility system, a long-lived perennial life-form, a restricted seed dispersal and the geographical range –, but also the geographic location and pollinator behaviour appeared to be important factors for explaining the observed genetic patterns. The acquisition of these data in conjunction with ecological and demographic data will contribute to set up priorities for conservation and management of the remnant populations.

Genetic diversity in hybrid zones of plants: a matter of scale

Ludwig Triest

Algemene Plantkunde en Natuurbeheer, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussel, Belgium
ltriest@vub.ac.be

Hybrid zones of plants contain metapopulations with increased heterozygosity and allelic richness compared to the within-species populations only. The occurrence of hybrids and introgressed hybrids depends on the mode of reproduction, the distances of gene flow through pollen and seed. The dynamic nature of abiotic systems also may play a role in shaping the hybrid patches at local and regional scales. Hybrid zones from four plant groups (riparian trees, wetland-, forest- and aquatic plants) and at different landscape levels will be compared by using allozymes, nuclear DNA and chloroplast microsatellites. The model species groups are the outcrossing but also vegetatively propagating *Salix* and *Scirpus* species from dynamic riparian zones and estuarine conditions, the obligate outcrossing species of *Primula* and *Najas* from respectively agricultural landscapes and lakes and the facultative outcrossing mangrove trees (*Avicennia*, *Bruguiera*, *Rhizophora*) from tropical coastal habitat fragments.

**Research of chloroplast DNA markers by PCR-RFLP
in the genus *Dactylorhiza* (Orchidaceae)**Nicolas Devos, Anne-Laure Jacquemart, Olivier Raspé & Renate A. Wesselingh
Université Catholique de Louvain, Unité d'écologie et de biogéographie,
Croix du Sud, 4-5, B-1348 Louvain-La-Neuve, Belgium; devos@ecol.ucl.ac.be

This study is part of a research programme dealing with speciation and evolution of species within the genus *Dactylorhiza* (Orchidaceae). This genus presents a large number of species, despite the massive extinctions that occurred during the pleistocene glaciations. That suggests a high rate of speciation during the past 10000-15000 years. Moreover, *Dactylorhiza* species are very variable morphologically and their taxonomic status is not very well defined. Indeed, most of the species seem to have hybrid, auto- or allopolyploid origin.

Our aim is to use allozyme and chloroplast DNA markers to better understand the impact of hybridization, introgression and polyploidization on the evolution of the genus *Dactylorhiza* in North-West Europe.

Chloroplast DNA markers have never been used in this genus but are nevertheless very useful to follow hybridization and introgression between different taxa along maternal lines. Until now, several chloroplastic markers have been obtained by use of PCR-RFLP method. Eleven regions of the chloroplast genome were amplified using universal primers, and screened for fragment length polymorphism by digestion with four different restriction enzymes.

Dipsacales phylogeny revisited: combining two chloroplast genes with morphological data

Nancy Pyck & Erik Smets

Laboratory of Plant Systematics, Institute of Botany and Microbiology, K.U.Leuven,
Kasteelpark Arenberg 31, B-3001 Leuven, Belgium; nancy.pyck@bio.kuleuven.ac.be

As currently circumscribed, the order Dipsacales comprises six families: Caprifoliaceae (honeysuckle family), Diervillaceae, Dipsacaceae (teasel family), Linnaeaceae, Morinaceae and Valerianaceae (valerian family). This order, centred in the temperate regions, is best known for its numerous hardy ornamental shrubs. Notable among these are *Symphoricarpos* (snowberry, coralberry), *Lonicera* (honeysuckle), *Kolkwitzia* (beautybush) and particular species of *Abelia*, *Weigela* and *Centranthus*.

Till now, several phylogenetic hypotheses concerning intergeneric and interfamilial relations have been under debate, and the position of particular key taxa has been questioned. For example,

there are a lot of difficulties in classifying the Chinese shrub *Heptacodium* (seven-son flower) because the genus shares characteristic features of both Caprifoliaceae and Linnaeaceae. The position of the genus *Triplostegia*, consisting of erect perennial herbs from Southeastern Asia, has been questioned ever since the taxon was first described. The Eurasian Morinaceae have been controversial with respect to their rank and phylogenetic relations. In addition, the monophyletic nature of the primitive tribe Patrinieae in Valerianaceae is questioned.

In this study, nucleotide sequences of the plastid *ndhF* gene of all major lineages within the Dipsacales are supplemented with available *rbcL* sequences; combination with a morphological data set is also performed. In order to reconstruct a phylogenetic pattern of Dipsacales, all data sets are subjected to parsimony analyses, both separately and in combination.

All molecular data sets indicate that the traditionally circumscribed tribe Patrinieae can no longer be recognized and must be considered as a basal grade in Valerianaceae. The position of *Triplostegia* remains ambiguous: separate *ndhF* sequences and combined molecular data suggest a sister relation to the Dipsacaceae, while the morphological and total evidence analyses show *Triplostegia* as sister to all Valerianaceae. Morinaceae are heavily supported as a monophyletic family; possible inclusion in Valerianaceae or Dipsacaceae is hereby rejected. Resulting topologies from the *ndhF* analysis show a sistergroup relation between *Heptacodium* and all members of Caprifoliaceae. Trees inferred from the combined analyses suggest an unresolved basal position of *Heptacodium* in the Dipsacales.

Pollen of Rubiaceae: a portrait of morphological diversity

Suzy Huysmans¹, Steven Dessein¹, Steven Jansen¹, Frederic Lens¹, Stefan Vinckier¹,
Frederic Piesschaert¹, Petra De Block², Koen Es², Marcel Verhaegen²,
Piet Stoffelen², Elmar Robbrecht² & Erik Smets¹

¹ Laboratory of Plant Systematics, Institute of Botany and Microbiology, K.U.Leuven,
Kasteelpark Arenberg 31, B-3001 Leuven, Belgium; suzy.huysmans@bio.kuleuven.ac.be

² National Botanic Garden of Belgium, Domein van Bouchout, B-1860 Meise, Belgium.

The predominantly tropical family Rubiaceae is with ca. 13.000 species one of the largest families of angiosperms. Contrary to some other huge families, the pollen morphological variation within the Rubiaceae is impressive. Although the tricolporate pollen type dominates by far, a number of tribes (e.g., Psychotrieae, Spermacoceae, Sabiceae) are highly eurypalynous.

The portfolio presented is a summary of the pollen morphological observations achieved in the past seven years at the Laboratory of Plant Systematics and the National Botanic Garden of Belgium. We aim to explore thoroughly the pollen and orbicules morphological diversity of the Rubiaceae in order to assess the systematic value of the respective features and to define new characters.

The poster illustrates the variation for the main pollen morphological characters such as dispersal unit, size, shape, apertures, sexine pattern, wall stratification, inner nexine ornamentation. Orbicules are often present in the anthers of Rubiaceae and they can be spherical, doughnut-shaped, irregularly folded or spinulate. Their systematic value at generic and tribal level was demonstrated by our research.

Our poster is complemented by a separate explanatory text including figure captions. The database of all genera investigated with reference to our papers (see hand-out) will be available soon at <http://www.kuleuven.ac.be/bio/sys/pollen>.

Wood anatomical variation in Ericales sensu APG. A preliminary study of Ericaceae

Frederic Lens, Steven Jansen & Erik Smets

Laboratory of Plant Systematics, Institute of Botany and Microbiology,
Kasteelpark Arenberg 31, B-3001 Leuven, Belgium; frederic.lens@bio.kuleuven.ac.be

For several years, a huge amount of molecular data has greatly influenced the classification of flowering plants [APG 1998, Ann. Missouri Bot. Gard. 85: 531-553]. In this new system, the order Ericales is accepted as an enlarged complex of 24 families including, amongst others, the former Ebenales and Primulales. This project wants to present a detailed survey of the wood anatomical variation within the newly defined group. A first family under investigation are Ericaceae. In a later stage, the wood of Myrsinaceae, Theophrastaceae, Marcgraviaceae and paleotropical Sapotaceae will be studied in detail.

Molecular data show that Ericaceae s.s. (classical Ericaceae plus Vacciniaceae) do not form a monophyletic group unless Empetraceae, Epacridaceae and the herbaceous Pyrolaceae and Monotropaceae are included [Kron 1996, Ann. Bot 77: 293-303]. This broad circumscription of Ericaceae (adding up ca. 3780 species and 141 genera according to Mabberly 1997 [The plant-book, ed. 2, Cambridge University Press, Cambridge]) is not surprising since the above-mentioned families were traditionally considered to be closely related. In total 220 species out of 54 genera have been collected of which 122 species from 50 genera covering all tribes of the *Ericaceae* have been investigated light microscopically. The poster illustrates the wood characteristics observed until now.

Wood anatomically the family is rather homogeneous. Diffuse porosity is common. Most specimens show solitary and narrow vessel elements, which are densely distributed. Perforation plates are mostly scalariform or mixed scalariform/simple, sometimes exclusively simple. Vessel-ray pits have distinct to much reduced borders (apparently simple). Vessured pits are absent. Helical thickenings are present or absent. Non-perforated tracheary elements consist mostly of (vasicentric) tracheids and fibre-tracheids (exceptionally libriform fibres), but many samples also show few septate libriform fibres. The combined occurrence of different fibre types and the presence of tracheids within a single wood sample result from a so-called tracheid dimorphism [Carlquist 1988, Aliso 12: 103-118]. Axial parenchyma is rarely present and varies from a apotracheal to paratracheal distribution. Rays are heterogeneous (mostly heterogeneous type II [Kribs 1968, Commercial woods on the American Market, Dover Publications, New York]), and consist of two widths. Prismatic crystals in ray cells are not uncommon.

Obviously, the characters that show variability in the study group could be taxonomically important. These include the length of vessel elements and fibres, the type of vessel perforation plate, the presence of helical thickenings in tracheary elements, the width and height of rays, the variation in vessel-ray pits, and the occurrence of crystals.

Quelle applicabilité de la dendrochronologie en Afrique tropicale?François N. Kouamé¹, Valérie Trouet², Aliou Diouf³, Anouk Verheyden⁴,
Ismaïla Diallo⁵ & Hans Beeckman⁶¹ Laboratoire de Botanique, Université de Cocody (Côte-d'Ivoire) 01 BP 1303 Abidjan, Côte-d'Ivoire;
francois.kouame@csrs.ci² Katholieke Universiteit Leuven, Vital Decosterstraat 102, 3000 Leuven, Belgium; valerie.trouet@agr.kuleuven.ac.be³ Centre de Suivi Ecologique BP 15532 Dakar-Fann, Sénégal; diouf@cse.sn⁴ Algemene Plantkunde en Natuurbeheer, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussel, Belgium⁵ Institut Sénégal de Recherches Agricoles BP 2312 Dakar, Sénégal; isdiallo@hotmail.com⁶ Laboratoire de Biologie du bois, Musée Royal de l'Afrique Centrale B-3080 Tervuren, Belgium;
hans.beeckman@africamuseum.be

Les analyses dendrochronologiques sont importantes pour l'analyse de croissance des arbres et facteurs moteurs. Si pour les espèces ligneuses tempérées l'utilisation de la dendrochronologie a

été prouvée plusieurs fois, les espèces ligneuses tropicales n'ont fait l'objet que de peu d'investigations à ce jour. C'est ainsi que dans le but de combler le déficit d'informations sur ces arbres, des disques ont été récoltés sur différents arbres de plusieurs espèces dans quatre pays de l'Afrique Tropicale (Côte-d'Ivoire, Kenya, Sénégal, Zambie). Les disques proviennent d'une part de zones où la saison sèche est généralement plus longue que la saison des pluies et d'autre part de zones où la saison sèche est presque inexistante. L'analyse dendrochronologique a révélé l'existence de deux types de cernes. Les cernes normaux qui se caractérisent par une présence visible sur chacun des quatre axes du disque et les cernes localement absents qui eux ne sont pas concentriques et rejoignent par endroit les cernes concentriques. La présence, parfois en très grand nombre, de ces cernes localement absents dans les échantillons de bois tropicaux constitue la grande difficulté dans l'analyse dendrochronologique. La question est de savoir quelle signification physiologique ces cernes localement absents peuvent avoir. Leur présence rend difficile la corrélation entre la présence d'un cerne et l'activité cambiale d'une année de croissance de l'arbre. Qui plus est, le peu de connaissance de l'histoire des peuplements constitue souvent une contrainte majeure.

Pour surmonter cette difficulté, il apparaît important d'analyser plusieurs échantillons sur plusieurs sites et de connaître l'histoire des peuplements au sein desquels les récoltes ont été effectuées. Aussi serait-il important pour les espèces tropicales de combiner la dendrochronologie à l'étude anatomique du bois pour une meilleure compréhension des parenchymes impliqués dans les analyses dendrochronologiques.

Ces conditions réunies pourraient faciliter les analyses dendrochronologiques des bois tropicaux. Ceci conférerait aux analyses dendrochronologiques une place importante dans l'estimation du potentiel de production des formations forestières d'Afrique tropicale en complémentarité avec les méthodes conventionnelles d'inventaires forestiers. En conséquence, des plans rationnels pour une gestion durable des formations forestières pourront être élaborés avec une forte implication des populations circonvoisines, premières bénéficiaires des ressources.

Dendroclimatology of trees from the miombo woodland in Southern Africa

Valérie Trouet

Koninklijk Museum voor Midden-Afrika, B-3080 Tervuren, Belgium

In Southern and Eastern Africa, climate time-series provided by instrumental records scarcely exceed a time-span of one hundred years. This period is too short to comprise multiple realisations of decadal variability and thus to register long-term climate oscillations, such as the El Niño Southern Oscillation (ENSO). In addition to this, for large parts of Africa the network of climatological stations is not dense enough to present a coherent spatial image of climate variability. It is therefore imperative that other methods for establishing longer records can be developed.

Tree ring data are interesting for this purpose because they have a fixed annual resolution and can produce absolute time-series, two characteristics that are important in climate reconstruction. Dendrochronology, based on time-series from areas on the Northern Hemisphere, provides a good climate record. Tree ring analysis of tropical regions, however, is very limited.

The occurrence of annual rings in tropical tree species is restricted to regions with tropical wet- and dry- climate. Miombo woodland is the main vegetation type of the region with a tropical wet- and dry- climate in sub-Saharan Africa. It is dominated by three genera of the family of the Leguminosae: *Brachystegia*, *Isobberlinia* and *Julbernardia*. Even within this vegetation type, the potential to form annual rings is species-dependent and site-dependent.

The value of growth rings as proxy data for climate reconstruction was studied in several miombo woodland species in Southern and Eastern Africa. A total of twelve species was examined

from two sites in Tanzania and eight sites in Zambia. Species from both the wetter and the drier miombo woodland type were sampled.

The frequent appearance of growth ring anomalies hinders synchronisation of growth ring series. Growth ring anomalies were determined and located through microscopic analysis of complete stem discs. For each tree, growth ring widths were measured along four radii, using LINTAB equipment and TSAP software.

Synchronisation between radii proved to be possible for almost every tree, after elimination of growth ring anomalies. Synchronisation between mean growth curves of different trees of the same site, was not as successful. Where it was possible to build a representative mean growth curve for a number of sites, cross-dating of samples from other sites proved to be impossible. A key aspect could be degree of deciduousness, which is site- and species-dependent.

A response function analysis was performed between growth ring data from the different sites and precipitation and temperature data from nearby weather stations. Southern Oscillation Index (SOI)-values were also comprised as climatic data in the response function analysis. Three different response function analysis methods were implemented to ensure the significance of the response functions found: redundancy analysis, multiple linear regression and set correlation analysis.

The sites with a representative mean growth curve were examined in a response function analysis with climatic data. The results of this response function analysis determine the potential of the sites for climate reconstruction.

Assessing the potential of *Rhizophora mucronata* Lamk. wood in dendro-ecological research

Anouk Verheyden¹, Hans Beeckman², Jurgen Tack³ & Nico Koedam⁴

¹ Research assistant Fund for Scientific Research-Flanders (Belgium), c/o Research Group of General Botany and Nature Management, Mangrove Management Group, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussel, Belgium; averheyd@vub.ac.be

² Agricultural and Forestry-Economy – Xylotheek, Royal Museum for Central Africa, Leuvense Steenweg, 13, B-3080 Tervuren, Belgium

³ Institute for Nature Conservation, Biodiversity Platform, Kliniekstraat 25, 1070 Brussels, Belgium

⁴ Research Group of General Botany and Nature Management, Mangrove Management Group, Free University of Brussels, Pleinlaan 2, B-1050 Brussels, Belgium

Mangrove trees of the genus *Rhizophora* have been reported not to form tree rings (Panshin 1932, van Vliet 1976). However, *Rhizophora mucronata* Lamk. disks collected from two sites in the mangrove forest in Gazi, Kenya show a clear alternation of light brown and dark brown wood when polished. In tropical regions, proxy records of palaeoenvironment such as tree rings are limited (Verschuren 2000). This study examines whether the macroscopically visible colored zones are related to wood anatomical features and whether these colored zones could be incorporated in a tree ring analysis.

Microscopic investigation revealed that the macroscopically visible color alternation is a reflection of a difference in vessel frequency, light wood exhibiting higher vessel frequency (23-58 vessels/mm²) than dark wood (5-31 vessels/mm²). No distinct growth-ring boundaries could be detected. The transition between the colored zones is a gradual increase/decrease in vessel frequency. Vessel frequency was inversely correlated to radial and tangential vessel diameters (Spearman Rank: R= -0.517, p<0.001; R= -0.567, p<0.001, respectively). In order to define the growth zone boundaries, two methods were compared. A first method included visual delimitation of the light and dark zones and zone width measurements were obtained from LINTAB. A second method included measuring vessel frequency and mean tangential and radial vessel diameters in adjacent quadrats along a transect from pith to bark using an image analysis program (AnalySIS 3.0). Comparison of LINTAB data and vessel frequency measurements shows a visual as well as a statistical (Mann Whitney U-test p<0.001) correspondence. The delimitation of the growth zones

allows the further investigation of the suitability of *R. mucronata* wood for dendro-climatological and/or dendro-ecological studies.

References. – Panshin (1932) An anatomical study of the woods of the Philippine mangrove swamps. *Phillipp. J. Sci.* 48(2): 143-205. van Vliet G.J.C.M. (1976) Wood anatomy of the Rhizophoraceae. *Leiden Botanical Series* 3: 20-75. Verschuren D., Laird K.R. & Cumming B.F. (2000) Rainfall and drought in equatorial east Africa during the past 1,100 years. *Nature* 403: 410-414.

Holocene palaeoecology and climate history on South Georgia (sub-Antarctic) based on a plant macrofossil record

Nathalie Van der Putten¹, Herman Stieperaere², Cyriel Verbruggen¹ and Ryszard Ochrya³

¹ Laboratory for Palaeoecology and Landscapegenesis, Ghent University, Department of Geography, Krijgslaan 281, S8/A1, B-9000 Gent, Belgium

² National Botanic Garden of Belgium, Domein van Bouchout, 1860 Meise, Belgium

³ Laboratory of Bryology, Institute of Botany, Polish Academy of Sciences, Ul. Lubicz 46, PL-31-512 Cracow, Poland

This study represents the results of the first detailed analysis, using macroscopic plant remains, of a complete 14C-dated Holocene organic sequence from a sub-Antarctic island, South Georgia. In the infilling of a rock basin thirty-one bryophyte species and many of the principal species of the present day angiosperms, associated with bog communities, have been identified. The zonation of the bryophytes and the seeds and fruits diagrams shows a striking correspondence with the sediment stratigraphy, and indicates four ecological phases. The first three reflect a succession from a minerotrophic shallow pool to an ombrotrophic *Warnstorfia-Polytrichum* bog. After the deposition of a clastic layer, ca. 2200 BP, a wet *Deschampsia-Warnstorfia-Sanionia-Rostkovia* bog came into existence, which is still present today. The ecological phases are radiocarbon dated. They can be interpreted in terms of climate development during the Holocene.

Climate ameliorated rapidly at about 10000 years BP followed by a drier period. Around 8000 BP the climate became wetter and the following ca. 3000 yr probably represents the climatic optimum. Between 4500 BP and 2600 BP, drier conditions prevailed at the study site. The most striking change occurred at 2600 BP when a climatic deterioration took place followed by an important change in vegetation and ecology, indicating much wetter conditions.

Phytoremediation of heavy metals: the role of macrophytes in a stormwater basin

Anne-Christine Gouder de Beauregard & Gregory Mahy

Faculté Universitaire des Sciences Agronomiques de Gembloux, Ingénierie des biosystèmes, Laboratoire d'Ecologie, Passage des Déportés, 2, B-5030 Gembloux, Belgium; gouder.ac@fsagx.ac.be

This study was undertaken in the 'Plateau des Tailles' (1200 mm precipitation/year) at Cédrogne's storm water basin, Belgium (3 sub-basins: 270 sq. m, 540 sq. m, 540 sq. m). Heavy metals, such as cadmium, zinc, lead and iron, are released from local highways in the water runoff because of the road traffic. At present, a few water basins like Cédrogne are dedicated to phytoremediation in the country. Biological epuration of heavy metals has been undertaken by submerged, aquatic and semi-aquatic macrophytes. Some of the vegetation was introduced artificially (i.e. *Typha latifolia* L., *Sagittaria sagittifolia* L.) and other species appeared naturally in each basin (i.e. *Elodea canadensis* Michaux).

The aim of the study was to prove the efficiency of aquatic vegetation to assimilate heavy metals. A decrease of heavy metals concentrations within the plants, and also in the waters and sediments from the inlet to the outlet was used to test this hypothesis.

Results showed that heavy metals (Fe excepted) are not highly concentrated in the waters, due to the inflow collecting mixed waters from highways and natural wetlands nearby. However, concentrations of heavy metals are higher in the aquatic vegetation (roots, stems, leaves) and in the

sediments. *Elodea canadensis* is the most appropriate species for bioaccumulation of heavy metals and can accumulate 10 to 40 times more Cd, 4 to 20 times more Pb and 4 to 8 times more Zn than any other plant species (exportable parts). A decrease of heavy metals is shown between the inlet and the outlet.



Appendix

Belgian botanical journals and series *Belgische botanische tijdschriften en reeksen* Périodiques et séries botaniques belges

A selection drawn from the database BIODIV by Guido Rappé (National Botanic Garden of Belgium, Meise)

This list contains the major ongoing or recently ended journals and series that report regularly or occasionally on Belgian botanical biodiversity. Some are dedicated to botany in general, some to a subdiscipline, some to biology or natural history in general, in the latter case including contributions on fauna.

The list is in no respect exhaustive, as some local working groups or local divisions of national associations edit a journal and/or newsletter of their own, which may contain original information. It is the 'natural' task of a major dedicated library like the one at the National Botanic Garden of Belgium, to keep track of any original information on the national botanic biodiversity. If your publication(s) contain original information and the National Botanic Garden of Belgium is not on your mailing list, please contact the library and BIODIV.

The format of the listing is as follows:

- official title (can be bilingual – if necessary with information on change of title);
- first year-last year;
- publisher;
- information on the (sub)disciplines covered by the contents (given between brackets).

Deze lijst bevat de belangrijkste lopende of recent stopgezette tijdschriften en reeksen die regelmatig of occasioneel berichten over de Belgische botanische biodiversiteit. Sommige zijn gewijd aan plantkunde in het algemeen, sommige aan een beperkter werkterrein, sommige aan biologie of veldbiologie in het algemeen (in het laatste geval eventueel ook bijdragen over de fauna bevattend).

De lijst is niet uitputtend. Veel lokale werkgroepen en afdelingen van nationale verenigingen geven een eigen tijdschrift of nieuwsbrief uit, dat ook originele informatie kan bevatten. Het is de 'natuurlijke' taak van een grote gespecialiseerde bibliotheek zoals deze van Nationale Plantentuin van België, om alle originele informatie over de Belgische botanische biodiversiteit bij te houden. Als uw uitgave(n) in aanmerking komen en u merkt dat de Nationale Plantentuin van België niet op uw verzendlijst staat, gelieve dan contact op te nemen met de bibliotheek en BIODIV.

De vorm van de lijst is als volgt:

- officiële titel (kan tweetalig zijn – indien nodig met uitleg over verandering van titel);
- eerste jaar-laatste jaar;
- uitgever;
- informatie over het betreffende werkterrein (in het Engels, tussen haakjes).

Cette liste contient les principaux journaux et séries qui parlent régulièrement ou occasionnellement de la biodiversité, qui sont toujours publiés ou qui ont été arrêtés récemment. Certains sont consacrés à la botanique en général, certains à une de ses sous-disciplines, les autres à la biologie et à l'histoire naturelle, ces derniers pouvant inclure des contributions faunistiques.

La liste n'est en aucun cas exhaustive, parce que certains groupes de travail locaux ou divisions locales d'associations nationales éditent un journal plutôt confidentiel mais qui pourrait contenir des informations de première main. C'est le rôle 'naturel' d'une bibliothèque aussi spécialisée que celle du Jardin botanique national de Belgique de rechercher les informations originales, quelles qu'elles soient, sur la biodiversité botanique belge. Si votre/vos publication(s) contiennent des informations originales et que le Jardin botanique national de Belgique ne figure pas sur votre liste d'adresses, veuillez contacter la bibliothèque du Jardin et BIODIV.

Le format de la liste est le suivant:

- titre officiel (peut-être bilingue – si nécessaire avec des indications de changement de titre);
- première année-dernière année;
- éditeur;
- informations sur les (sous-)disciplines couvertes (en anglais, entre parenthèses).

Adoxa, 1993-ongoing. Amicale Européenne de Floristique (AEF), Bruxelles (floristics in Wallonia and Brussels).

AMK Mededelingen, 1983-ongoing. Koninklijke Antwerpse Mycologische Kring vzw (KAMK), Antwerpen (mycology).

ANKONA Jaarboek, 1998-ongoing. Antwerpse Koepel voor Natuurstudie, Antwerpen (natural history, Antwerpen province)

Belgian Journal of Botany (formerly 'Bulletin de la Société Royale de Botanique de Belgique/- Bulletin van de Koninklijke Belgische Botanische Vereniging'), 1862-ongoing. Royal Botanical Society of Belgium (RBSB), Meise.

Biologisch Jaarboek Dodonaea (continuation of 'Botanisch Jaarboek', 1889-1934), 1934-1999. (Koninklijk Natuurwetenschappelijk Genootschap Dodonaea, Gent (biology and natural history).

BRAKONA Jaarboek, 2000-ongoing. Vlaams-Brabantse Koepel voor Natuurstudie, Leuven (natural history, Vlaams-Brabant province).

Bulletin (or 'Bulletins' in the first volumes) de la Société Royale de Botanique de Belgique – Bulletin van de Koninklijke Belgische Botanische Vereniging: see 'Belgian Journal of Botany'.

Bulletin du Jardin Botanique National de Belgique – Bulletin van de Nationale Plantentuin van België : see 'Systematics and Geography of Plants'.

De Heksenkring, 1981-ongoing. Zelfstandige werkgroep voor Amateur-Mycologen (ZWAM), Kessel-Lo (mycology).

De Levende Natuur, 1896-ongoing. Stichting De Levende Natuur, Utrecht (originally a Dutch journal on natural history, since 1984 Dutch-Flemish, focused on nature management).

De Strandvlo, 1981-ongoing. De Strandwerkgroep, Oostende (marine natural history, occasionally on seaweeds).

- Dumortiera, 1975-ongoing. National Botanic Garden of Belgium (NPB), Meise (floristics, vegetation).
- Jaarboek Natuurstudie Oost-Brabant, 2000-ongoing. Natuurpunt Oost-Brabant, Kessel-Lo (natural history in general, eastern part of the province Vlaams-Brabant).
- Jaarboek van de Vlaamse-Mycologen-Vereniging, 1997-ongoing. Vlaamse-Mycologen-Vereniging vzw, Gent (mycology).
- Lejeunia (since 1961 as 'Lejeunia. Nouvelle Série'), Revue de Botanique, 1937-ongoing. Cercle de Botanique Liégeois et de sa Section de Mycologie, Département de Botanique, Université de Liège (botany).
- Les Naturalistes belges, 1920-ongoing. Les Naturalistes belges, Bruxelles (biology and natural history in general).
- LIKONA Jaarboek, 1991-ongoing. Limburgse Koepel voor Natuurstudie, Genk (natural history in general, Limburg province).
- Liparis, 1995-ongoing. Studiegroep Europese en Mediterrane Orchideeën S.E.M.O. Vlaanderen (SEMO), Antwerpen (European and Mediterranean orchids).
- Mededelingen Instituut voor Natuurbehoud, 1995-ongoing. Instituut voor Natuurbehoud, Brussel (miscellaneous contributions on Flemish nature).
- Miscellanea Mycologica, nouvelle série. 1983-ongoing. Cercle de Mycologie de Mons asbl (CMM), Mons (mycology).
- Muscillanea,, 1981-ongoing. Vlaamse Werkgroep Bryologie en Lichenologie (VWB), Brussel (bryology and lichenology).
- MYCOLUX (formerly 'MYCO'), Bulletin trimestriel des Mycologues du Luxembourg belge, 1989-ongoing. Mycologues du Luxembourg Belge asbl (MLB), Neufchateau (mycology).
- Natura Mosana, 1948-ongoing. Sociétés des Naturalistes Namur-Luxembourg, Namur (natural history in Wallonia).
- Natuur.focus (see also 'Wielewaal', 2002-ongoing. Natuurpunt, Mechelen (natural history, nature conservation and management in Flanders).
- Natuurhistorische reeks, 1999-ongoing. Natuurpunt, Mechelen (miscellaneous series on natural history in Flanders).
- Nieuwsbrief Mossen en Lichenen-Planten-Paddestoelen, 2001-ongoing. Natuurpunt, Mechelen (bryology and lichenology, vascular plants, mycology).
- Nowellia bryologica, 1992-ongoing. Centre Marie-Victorin, Vierves-sur-Viroin (bryology).
- Orchidées, 1986-ongoing, published as a special issue of 'Les Naturalistes belges'. Section Orchidées d'Europe of 'Les Naturalistes Belges asbl', Bruxelles (European orchids).
- Parcs & Réserves (formerly 'Parcs nationaux'), 1946-ongoing. Ardenne & Gaume, Gembloux (focused on nature conservation and management in Wallonia).
- Revue du Cercle de Mycologie de Bruxelles, 2001-ongoing. Les Naturalistes Belges asbl, Bruxelles (mycology).
- Scripta Botanica Belgica, 1992-ongoing. National Botanic Garden of Belgium (NPB), Meise (miscellaneous botanical documentation).

- Société pour l'Echange des Plantes vasculaires de l'Europe et du Bassin méditerranéen, (Associated Herbaria for the Exchange of Vascular Plants of Europe and the Mediterranean region) (Formerly 'Société Française pour l'Echange des Plantes Vasculaires Bulletin'), Bulletin, 1972-2001. Département de Botanique, Université de Liège, Liège.
- Sterbeeckia, 1961-ongoing. Koninklijke Antwerpse Mycologische Kring vzw (KAMK), Antwerpen (mycology).
- Streepzaad, 1995-ongoing. FLO.WER vzw, Meise (floristics in Flanders).
- Systematics and Geography of Plants, (formerly 'Bulletin du Jardin Botanique National de Belgique – Bulletin van de Nationale Plantentuin van België'), 1902-ongoing. National Botanic Garden of Belgium (NPB), Meise (focused on tropical plants, occasionally on Belgium).
- Wielewaal (merged into 'Natuur.focus'), 1934-2001. De Wielewaal, Turnhout (natural history, mainly birds and fauna, in Flanders).



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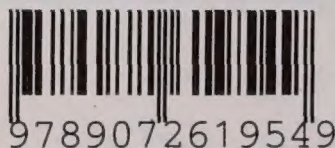
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